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SOME NEW *SPHACELOMA* DISEASES OF ECONOMIC PLANTS IN MYSORE

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(With 9 Text-figures)

Species of the genus *Sphaceloma* de Bary, with their ascigerous stage *Elsinoe* Racib., have received a good deal of attention from plant pathologists on account of the scab or anthracnose disease they produce on plants of economic importance. Recent monographic studies by Dr A. A. Bitancourt and Dr A. E. Jenkins have greatly advanced our knowledge of the group. In India, only two *Sphaceloma* stages are known: one is *S. Fawcettii* Jenkins, which is the conidial stage of *Elsinoe Fawcettii* Bitan. & Jenkins, recorded on species of *Citrus* (Jenkins & Fawcett, 1933) and on *Hesperethusa crenulata*, from Bengal (Jenkins, 1936); the other is the *Sphaceloma* stage of *Elsinoe Bitancourtiana* Thirumalachar, recently described by me (1946). In collections made in Mysore, four more species of *Sphaceloma* were found, some of the hosts being plants of economic importance. Further studies are being made to investigate the possible existence of the ascigerous stages. An account of the *Sphaceloma* stages is presented here.

(1) A *SPHACELOMA* DISEASE OF *SANTALUM ALBUM* L.

Santalum album, the sandal tree, is of great economic importance on account of the valuable essential oil contained in the heart wood. Diseases of the sandal tree have been the subject of several detailed investigations in India. A species of *Sphaceloma* was found parasitizing the leaves in some of the collections made by me in the Mysore forests. The infected leaves have a warty surface with copper-coloured patches on the upper surface, and tend to roll and curl inwards. In association with *Asterina congesta* Cke. and an *Oidium*, which are also found as leaf parasites on *Santalum album*, the damage caused by the *Sphaceloma* is important, for the affected leaves fall long before healthy leaves. As no detailed search has been made in the sandal-growing areas of Mysore for studying the spread of the disease, it is not possible to evaluate the extent of the damage.

The infection first appears as cinereous areas on the upper surface, which gradually turn purplish to black, appearing as discolorations. The acervuli are intra-epidermal in origin and are distributed on either surface of the leaves. They rarely coalesce, and even where they are in close proximity the demarcation between the individual sori is still visible. The conidiophores are developed from scanty stromata or hyphal cells which become indistinguishable in later stages. The conidiophores are grouped in plumose tufts (Fig. 1), 43–60 μ long and 2–2.5 μ broad, hyaline, thin-walled and pointed at the apex. The conidia are produced in succession at the tip. They are hyaline, thin-walled, ovate to ellipsoid (Fig. 2), measuring

5-9 \times 2.5-3 μ . No species of *Sphaceloma* has so far been described on any of the members of the Santalaceae, and comparison with the described species indicates that the species on *Santalum* is new.

***Sphaceloma Santali* Thirumalachar, n.sp.**

Producing cinereous patches on the upper leaf surface, sometimes with purplish to black tinge and appearing as brown to black discolorations. Acervuli amphigenous, but mostly epiphyllous, intra-epidermal, 60-140 μ broad, 43-60 μ high, not coalescing with one another; conidiophores 43-60 μ long, produced in plumose tufts and developed from scanty stromata or hyphal cells which are indistinguishable later on; conidia produced acrogenously, hyaline, ovate-elliptic, measuring 5-9 \times 2.5-3 μ .

Habitat. On the leaves of *Santalum album* L., Lakkavalli, Mysore State, leg. M. J. Thirumalachar, 14 October 1945. Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, in the Imperial Mycological Institute, Kew, England, and in the Instituto Biologico, Sao Paulo, Brazil.

Producit cinereas maculas in superfore facie foliorum, nonnumquam pallide purpurescentes vel nigras, quae et brunneo-nigrae discolorationes apparent. Acervuli intra-epidermales, amphigeni sed ut plurimum epiphylli, latitudine 60-140 μ , altitudine 43-60 μ , haud coalescentes inter se; conidiophori 43-60 μ longi, plumose caespitosi, evoluti ex stromatis vel hypharum exiguis cellulis quae postea indistinctae evadunt, 43-60 μ longi, apice acuto; conidia acrogene producti in apice, hyalina, ovata vel elliptica, magnitudinis 5-9 \times 2.5-3 μ .

In foliis *Santali albi* L., Lakkavalli, Mysore State, leg. M. J. Thirumalachar, 14. 10. 1945.

(2) A NEW *SPHACELOMA* ON *OSYRIS WIGHTIANA* WALL.

Osyris Wightiana, a member of the Santalaceae, is a partial root parasite in the hilly districts of Mysore. The heart wood of the plant is very faintly fragrant, and is often used for adulterating sandal wood. Some collections of the leaves of this plant made near Nandi Hills, Mysore State, possessed concentric leaf spots in association with the epiphyllous ascomycetous fungus *Meliola Osyridicola* Hansf. which forms large sooty blotches masking the infection spots of the *Sphaceloma*. The infection spots are minute, amphigenous, arranged in perfect concentric rings (Fig. 3). The oldest acervuli are situated in the centre, the infection spreading centrifugally. Macroscopically, the acervuli appear as minute depressions on the surface of the leaves.

Sections through the infection spot show that the sori are intra-epidermal, formed by the grouping of a stroma of hyphal strands (Fig. 4). The cells of the host beneath the sori become depleted of their contents and turn orange coloured and canker-like. Palisade layers of conidiophores that are differentiated from the stroma, break through the upper wall of the epidermis and the cuticle, and abstrict off conidia. The mature conidia are hyaline, one-celled, ovate to globose (Fig. 5) and measure 3 \times 2.5 μ . This species of *Sphaceloma* differs from *S. Santali* in the nature of the sori and other characters, such as the length of the conidiophores.

***Sphaceloma* *Osyridis* Thirumalachar, n.sp.**

Infection spots amphigenous, appearing as minute depressions, arranged in perfect concentric rings. Acervuli intra-epidermal, composed of strands of hyphae and a palisade layer of conidiophores, not coalescing with each other and not becoming continuous. Conidia hyaline, acrogenous, ovate to spherical, thin-walled, measuring $3 \times 2.5 \mu$.

Habitat. On the leaves of *Osyris Wightiana* Wall., Nandi Hills, Mysore State, leg. M. J. Thirumalachar, 19 February 1944. Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, in the Imperial Mycological Institute, Kew, England, and in the Instituto Biologico, São Paulo, Brazil.

Infectionis maculae amphigenae, apparentes ut minutae depressiones, dispositae in circulis perfecte concentricis. Acervulus intra-epidermalis, constans ex hypharum fasciculis atque strato conidiophorum, non coalescens cum aliis nec cum illis continuus evadens. Conidia hyalina, acrogena, ovata vel sphaerica, tenuiter parietata, magnitudinis $3 \times 2.5 \mu$.

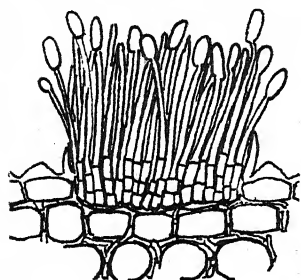
In foliis *Osyridis Wightiana* Wall. in loco Nandi Hills, Mysore State, leg. M. J. Thirumalachar, 19. 2. 1944.

(3) AN ANTHRACNOSE DISEASE OF OLEANDER LEAVES

Collections of oleander leaves made by me near Koppa Road, Mysore, were severely parasitized by a *Sphaceloma*. Another collection of the same fungus made near Kemmangundi, a hill station in Mysore, was also examined. The lesions on the leaves were circular to irregular, whitish, bordered by a brownish black margin (Fig. 6). By the coalescence of these lesions, the infection patch enlarges and occupies most of the leaf surface. When examined with a lens, the surface of the infected patch presents a punctiform to verrucose appearance. In severe infection, there is heavy defoliation of the plants.

The acervuli are amphigenous but mostly epiphyllous and are grouped on the infection spots. They are intra-epidermal, formed by the grouping of the hyphal strands within the epidermis. As is well known, the epidermis in *Nerium oleander* possesses two to three layers and it has been observed that the acervuli are formed in all three layers. Especially when the sori are formed within the innermost layer of epidermis, the developing sorus breaks through the two superposed epidermal layers, appearing as subepidermal in origin. The acervuli coalesce when they are developed in close proximity and thus become continuous.

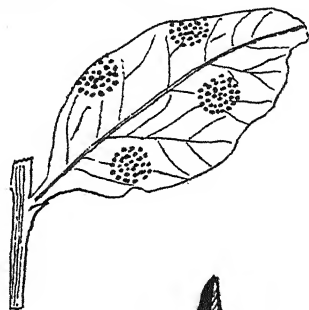
The fundamentals of the sori are formed by the grouping of the hyphae which form a thick well-developed stroma of several tiers of cells (Fig. 7). The conidiophores are indistinguishable from the rest of the cells of the stroma, except that they are the terminal group of cells. These rupture the upper wall of the epidermis and develop acrogenously hyaline, spherical conidia (Fig. 8) which are thin-walled and measure $4-5 \times 2.5-4 \mu$. No species of *Sphaceloma* has previously been reported to occur on *Nerium* or its allied genera and the present species cannot be accommodated in any of the previous species so far described.



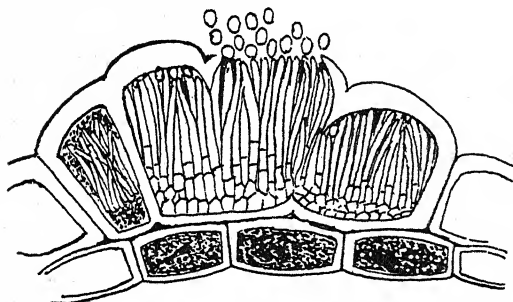
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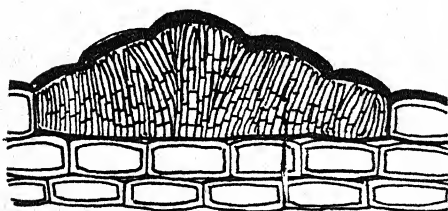
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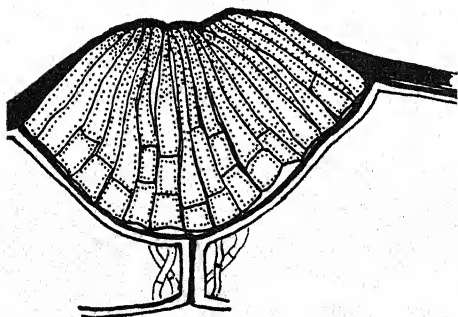
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***Sphaceloma Oleanderi* Thirumalachar, n.sp.**

Leaf spots spherical to irregular, densely grouped, 1-4 mm. in diam. distributed over the entire surface of the leaves, whitish with a brownish black margin, slightly elevated and appearing rugged owing to the punctiform masses of *Sphaceloma*. Acervuli are intra-epidermal, formed in the first, second or the third layers of the upper epidermis, seldom amphigenous, often becoming coalescent, 140-200 μ in diam. and 60-85 μ high; stroma well developed with several tiers of cells; conidiophores short, 5-6.5 \times 2-2.5 μ , breaking through the upper wall, developing acrogenously hyaline, thin-walled conidia which measure 4-5 \times 2.5-4 μ .

On the leaves of *Nerium Oleander*, Koppa Road, leg. M. J. Thirumalachar, 3 April 1945, leg. H. C. Govindu, Kemmangundi 10 October 1945 (Type). Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, in the Imperial Mycological Institute, Kew, England, and in the Instituto Biologico, São Paulo, Brazil.

Foliorum maculae sphaericae vel irregulares, dense aggregatae, 1-4 mm. diam., dispersae per totam foliorum faciem, albidae margine fusco-nigro, tenuiter elevatae atque asperae ob punctiformes massas Sphacelomatis. Acervuli intra-epidermales, producti intra primum, secundum vel tertium stratum epidermatis superioris, raro amphigeni, saepe inter se confluentes, ut plurimum 60-85 \times 140-200 μ , stromate bene evoluto multiplice cellularum ordine; conidiophori breves, 5-6.5 \times 2-2.5 μ . perforantes exteriorem epidermatis parietem; conidia acrogene producta, hyalina, tenuiter-parietata, magnitudinis 4-5 \times 2.5-4 μ .

In foliis *Nerii Oleanderi*; Koppa Road, Mysore, leg. M. J. Thirumalachar, 3. 4. 1945; leg. H. C. Govindu, Kemmangundi, 10. 10. 1945 (Typus).

(4) A LEAF-SPOT DISEASE OF *CURCUMA* CAUSED BY A SPECIES OF *SPHACELOMA*
Indigenous species of *Curcuma* are well distributed in the forests of Mysore. The rhizomes of many of these wild turmeric are used as an additional source of starch by the local people. In one species of *Curcuma* it was observed that the leaves had developed numerous small lesion spots, which on examination proved to be caused by an undescribed species of *Sphaceloma*. The lesions are brownish yellow, circular to ovate, 2-4 mm. in diam. and mostly found on the upper surface.

Sections through these infection spots revealed that the acervuli are subcuticular (Fig. 9) and very rarely, and then probably exceptional,

Legends for Figures 1-9

- Fig. 1. Acervulus of *Sphaceloma Santali*. (\times 500.)
- Fig. 2. Spores of *Sphaceloma Santali*. (\times 1000.)
- Fig. 3. Showing the infection spots of *Sphaceloma Oxyridis*. (Nat. size.)
- Fig. 4. Acervulus of *Sphaceloma Oxyridis*. (\times 500.)
- Fig. 5. Spores of *Sphaceloma Oxyridis*. (\times 1500.)
- Fig. 6. Anthracnosed leaf of *Nerium Oleander*. (Nat. size.)
- Fig. 7. Showing the intra-epidermal acervulus in *Sphaceloma Oleanderi*. (\times 250.)
- Fig. 8. Spores. (\times 1000.)
- Fig. 9. Acervulus of *Sphaceloma curcumae*. (\times 800.)

intra-epidermal. A compact layer of somewhat pale pseudoparenchymatous cells is produced. From this basal stroma, palisade layers of conidiophores are differentiated which are fusiform and become pointed at the apex. The conidiophores become laterally united and thus present a compact appearance. Most of the acervuli were found to be immature and only very young spores in the process of abstriction at the tip have been observed. Consequently the size and shape of the mature conidia remain unknown. The host cells and the entire stroma of the acervulus contained numerous microconidia. Such microconidia were found by Jenkins and Bitancourt in a number of species of *Elsinoe*. This is apparently the first record of *Sphaceloma* on the Zingiberaceae.

***Sphaceloma Curcumae* Thirumalachar, n.sp.**

Acervuli subcuticular, epiphyllous, round or irregular, minute, $31-50\mu$ in diam., pale yellow, composed of compact pseudoparenchymatous cells with conidiophores which are palisade-like and coalesce laterally, $20-25\mu$ long; conidia not observed, microconidia numerous and filling up the cells.

On leaves of *Curcuma* sp., Kemmangundi, Mysore State, leg. M. J. Thirumalachar, 9 October 1945. Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, Imperial Mycological Institute, Kew, England, and in the Instituto Biologico, São Paulo, Brazil.

Acervuli subcuticulares, epiphylli, globosi vel irregulares, minuti, $31-50\mu$ lati, 31μ alti, pallide lutei, compositi ex compactis pseudoparenchymaticis cellulis, conidiophoris vallatis atque lateraliter coalescentibus, $20-25\mu$ longis; conidia haud visa, microconidia plurima, cellulas implentia.

In foliis *Curcumae* sp., Kemmangundi, Mysore State, leg. M. J. Thirumalachar, 9. 10. 1945.

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SOME FUNGAL DISEASES OF BRYOPHYTES IN MYSORE

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(With 8 Text-figures)

The fungi associated with or parasitizing the thalli of the liverworts have attracted the attention of numerous investigators. A brief review of the various facts pertaining to this subject is given by Nicolas (1932). The fungi are usually found only in association with the gametophytes and it is uncertain if they are weak parasites or symbionts. The possible occurrence of a mycorrhizal fungus within the thallus of *Marchantia* was pointed out by Kashyap (1916) in India, and recently Mahabale & Bhate (1945) have recorded the presence of a mycorrhizal fungus in the ventral tissue of the liverwort *Fimbriaria angusta* St. As regards the disease-producing fungi on liverworts in India, the life cycle of *Phaeosphaerella Ricciae* F. L. Steph. parasitizing the gametophytes of *Riccia himalayensis* St. was described by Srinivasan (1939). In the course of the collection of material of Hepaticae by me for class work, the occasional presence of fungi as parasites was noticed. Since no fungi were suspected to be present at the time of collection, the materials were preserved in formalin alcohol and consequently they were unfit for undertaking any germination or cultural studies.

(1) A *CLADOCHYTRIUM* PARASITIC ON *ANEURA* SP.

In some of the collections of gametophytes of *Aneura* sp. made near Agumbe, Mysore State, many of the thalli had developed discoloured patches. In place of the healthy green colour, the affected patches had turned straw yellow. A detailed examination of such thalli indicated that they were parasitized by a species of *Cladochytrium*. No species of *Cladochytrium* has so far been recorded from India, but another genus of the family Cladochytriaceae, *Nowakowskiella ramosa* Butler, was reported on decaying wheat stems by Butler (1907).

The fungus is intramatrical, the 'rhizomycelium' pervading the cells of the host and forming extensive branches. At short intervals the rhizomycelium swells up and forms spindle-shaped swellings or the turbinate organs (Figs. 1, 2) which are very characteristic of the family Cladochytriaceae. These spindle-organs are mostly continuous (Fig. 2) without any wall formation, but sometimes (Fig. 1) they are definitely septate. It might therefore be well to consider the spindle organs in the present species as being sparsely septate. In distinguishing between the genera *Cladochytrium* and *Nowakowskiella*, the presence of an operculum in the zoosporangium of the latter is stated to be an important character, and Whiffen (1943) considers that the presence of the septations in the spindle-organs of *Cladochytrium* adds another differentiating character. The spindle-organs of *Nowakowskiella* are therefore regarded as unseptate and continuous.

Zoosporangia and resting spores were observed in large numbers. The zoosporangia are terminal or intercalary, their size and shape varying according to the host cell in which they are lodged. The division of the contents of the zoosporangium into zoospores was frequently noticed (Fig. 3), but their actual discharge could not be followed on account of the preserved state of the material. On some old zoosporangia, small papillate structures which might represent the remnants of the exit tubes were seen. The resting spores are ovate to spherical, cinnamon-yellow, thick-walled and smooth. The mature spores are often formed by the transformation of the spindle-organs and measure $30-44\mu$ in diam.

While species of *Cladochytrium*, such as *C. replicatum* Karling, are considered to be very weak parasites or almost saprophytes, other species, such as *C. Nowakowskii* Sparrow (Sparrow, 1931), is stated to be a virulent parasite on algae. The discoloration produced in the thalli of *Aneura* by the species under study shows that it might also be a weak parasite. Inoculation experiments carried out by Karling (1931) indicated that the species of *Cladochytrium* possess wide host ranges and the identity of the species therefore on the basis of host alone would be erroneous. *C. replicatum*, for instance, has been successfully inoculated into several hosts, including the liverwort *Anthoceros* (Karling, 1931). That being so, the identity of the species should be based on morphological characters and spore measurements alone. The sparsely septate nature of the spindle-organs, the inconspicuous, papillate exit-tube and the difference in size of the resting spores as compared with those of most of the species of *Cladochytrium*, has led me to the view that the species may be an undescribed one, though future investigations may reveal it to be identical with some well-established species.

***Cladochytrium Aneurae* Thirumalachar n.sp.**

Thallus intramatrix consisting of fine tenuous branched rhizomycelium with numerous spindle-shaped swellings which rarely become septate; zoosporangia spherical to oval, depending upon the shape of the host cell, often with a single constricted exit pore. Resting spores terminal or intercalary, often formed by the transformation of spindle-organs, usually intramatrix, ovoid to spherical, cinnamon-yellow, thick-walled, smooth, measuring $30-44\mu$ in diam.

Habitat. As a weak parasite within the thallus of *Aneura* sp. (Jungermanniales), Agumbe, leg. M. J. Thirumalachar, 4 April 1945. Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, and in the Imperial Mycological Institute, Kew, England.

Thallus intramatrix constans ex gracili tenuique atque ramoso rhizomycelio ornato plurimis fusiformibus tumoribus qui raro septati evadunt; zoosporangia sphaerica vel ovata pro forma cellulae parasitatae, $52-100\mu$ diam., unico constricto exitus poro. Quiescentes sporae terminales vel intercalares, saepe evolutae ex transformatione fusiformium organorum, plerumque intramatrix, ovatae vel sphaericae, cinnamonomoluteae, crasso pariete ornatae, leves, magnitudinis $30-44\mu$.

Parasitus debilis intra thallum *Aneurae* sp. (Jungermanniales) in loco Agumbe; leg. M. J. Thirumalachar, 4. 4. 1945.

(2) *OLPIDIOPSIS RICCIAE* DU PLESSIS

Olpidiopsis Ricciae Du Plessis was first described by Du Plessis (1933) within the rhizoids of *Riccia* in South Africa. Large numbers of sporangia and oospores were observed by him within the normal and pegged rhizoids. The presence of a companion-cell which in fact represents the empty antheridium attached to the oospore is a characteristic feature. The oospores have been observed within the rhizoids and rarely within the epidermal cells of *Riccia*, and the host range of the fungus is as yet unknown.

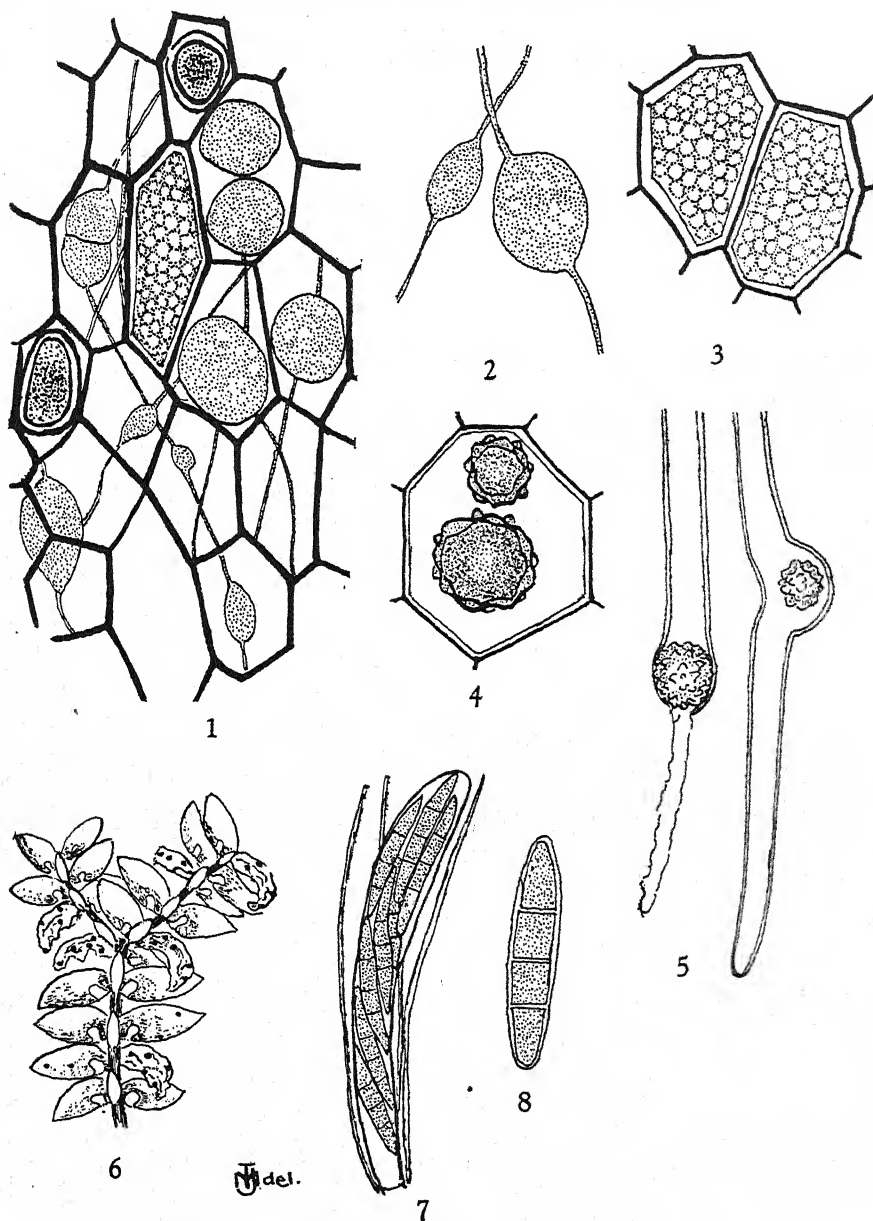
An *Olpidiopsis* which seemed to be identical with *O. Ricciae* Du Plessis was found by me within the rhizoids of many Hepaticae in addition to *Riccia*. The oospores have been found in the rhizoids of species of *Marchantia*, *Plagiochasma*, *Fimbriaria*, *Aneura* and *Notothylas*. It seems therefore probable that the fungus may have a wide host range.

Most of the oospores found were mature. They are yellowish brown with a sinuous outer wall. The companion-cell is mostly lacking from the mature spores; Du Plessis also records this. Whiffen (1942) states that *Olpidiopsis Aphanomyces* Cornu lacks the characteristic companion-cell. When the oospores are present in large numbers it seems that the cell contents of the rhizoids become depleted and shrivel up. Sometimes, as in the rhizoids of *Aneura*, at the place where the young oospore is lodged, the rhizoid turns and twists, forming a nodular structure indicating a definite necrotic effect (Fig. 5). In other specimens the definite shrivelling up of the rhizoid from the free end is noticeable. It might be of interest to take into account the view put forward by Du Plessis about the relationship. Because there were no visible signs of necrotic effect produced by the oospores, Du Plessis suggested that the relationship between the host and *Olpidiopsis Ricciae* might be one of symbiosis. My observations on what seems to be the same species of *Olpidiopsis* indicate that there is weak parasitism as in *Cladophytrium*, becoming discernible in certain hosts or when the host is not able to offer resistance.

In studying the host ranges for the species of *Olpidiopsis*, both Shanor (1940) and Whiffen (1942) pointed out that it is impossible to transfer any species of *Olpidiopsis* from the species of host on which it was collected to the host of any other species. No such studies have been made in the present investigation to confirm this interesting observation, but, because of the close morphological resemblance of the oospores found in the rhizoids of the various liverworts, the fungus in all the hosts is referred to *O. Ricciae*.

(3) *A LEPTOSPHERIA PARASITIC ON PORELLA*

Species of *Porella* are very commonly found as epiphytes on the branches and leaves of forest trees. In some of the collections of *Porella* made in Nandi Hills, Mysore State, the leafy lobes of the gametophyte were noticed to have been parasitized by an ascomycetous parasite, the infected leaves wilting away and finally drying up. Examination of the infected



Figures 1-8

- Fig. 1. Showing intramatrix thallus of *Cladochytrium Aneurae*. ($\times 400$)
 Fig. 2. Some of the unseptate spindle-organs. ($\times 600$)
 Fig. 3. Stages in the formation of zoosporangium. ($\times 800$)
 Fig. 4. Oospores of *Olpidiopsis Ricciae* within ventral tissue *Aneurae*. ($\times 1000$)
 Fig. 5. Oospores of *Olpidiopsis Ricciae* within the rhizoids. ($\times 500$)
 Fig. 6. Gametophyte of *Porella* with *Leptosphaeria* infection spots. ($\times 3$)
 Fig. 7. Ascus of *Leptosphaeria Porellae*. ($\times 800$)
 Fig. 8. Ascospore. ($\times 1800$)

leaves with a field lens, reveals numerous black specks distributed on the dorsal and ventral lobes as well as the amphigastria of the thallus (Fig. 6). The infection has been traced to a species of *Leptosphaeria*. The mycelium is intercellular, slightly dark, closely septate and ramifies within the tissues of the mesophyll. Numerous perithecia are distributed on the surface of the infected portions. They are minute, black, immersed within the thallus with the ostioles projecting as minute black specks. The asci are cylindrical, obovate at the apex, and associated with paraphyses. The ascospores are fusiform, rounded at both ends, hyaline, and usually three-septate. The spores are arranged in a biseriate manner and measure $15-20 \times 2.5-3.5 \mu$ (Figs. 7, 8). The association of the *Phoma* stage of the fungus with hyaline spores was observed. As no species of *Leptosphaeria* is so far known on any of the species of *Porella* or any other liverworts, it is not possible to institute any comparison. The name *Leptosphaeria Porellae* is proposed for the fungus.

***Leptosphaeria Porellae* Thirumalachar, n.sp.**

Perithecia on the foliose portions of the thallus, amphigenous, immersed in the early stages, later on becoming erumpent; black, spherical, ostiolate, ostiole projecting as a small papilla. Asci cylindric, 8-spored, $57-66 \times 6.5-7.5 \mu$, paraphysate; paraphyses numerous, simple, filiform; spores one to two-seriate, pale yellow, fusoid, rounded at both ends, smooth, slightly or not constricted at the septa, measuring $15-20 \times 2.5-3.5 \mu$.

Habitat. On the thallus and causing the wilting of *Porella* sp., Nandi Hills, Mysore State, leg. M. J. Thirumalachar, 10 February 1944. Type deposited in the Herb. Crypt. Ind. Orient., New Delhi, and in the Imperial Mycological Institute, Kew, England.

Perithecia super foliosas partes thalli, amphigena, initio immersa, postea erumpentia, nigra, sphaerica, ostiolata, ostiolo eminente ut papilla parva. Asci cylindrici, 8-sporei, $57-66 \times 6.5-7.5 \mu$, paraphysati; paraphyses plures, simplices, filiformes; sporae semel vel bis seriatae, pallide luteae, fusiformes, utroque apice rotundatae, leves, tenuiter vel nullo modo constrictae ad septa, magnitudinis $15-20 \times 2.5-3.5 \mu$.

In thallo *Porellae* spec., quem marcescentem reddit; in loco Nandi Hills, Mysore State, leg. M. J. Thirumalachar, 10. 2. 1944.

In conclusion the writer wishes to express his deep debt of gratitude to Rev. Father H. Santapau, Professor of Botany, St Xavier's College, Bombay, for kindly rendering into Latin the diagnosis of the new species. Grateful thanks are due to Dr B. B. Mundkur and Dr L. N. Rao for kind encouragement and valuable suggestions.

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THE AMBROSIA FUNGUS OF *XYLEBORUS FORNICATUS* EICH.

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(With Plate I and 26 Text-figures)

Many beetles of the family Scolytidae have long been known to live in association with specific fungi, the so-called 'ambrosia', which form the main, and possibly the sole food supply of their larvae. Yet little is known of these fungi, as may be seen from the review of the literature given by Leach, Hodson, Chilton & Christensen (1940).

Xyleborus fornicatus Eich., the shot-hole borer of tea, is an important ambrosia beetle pest in many tea districts of Ceylon, because the female beetles make galleries in living tea stems, which in consequence tend to break rather easily and so cause loss of crop. The beetle also invades other plants, of which the most important is the castor-oil tree. The beetle from tea is smaller than that from castor, measuring about 2.3 mm. in length as compared with 2.5 mm. from castor, and its elytral curve is more convex from scutellum to sutural apex. Because of these morphological differences, which, however, are not constant, Eggers (1922) described specimens from tea as a new species, *X. fornicator*. Sampson (1923) and Beeson (1925) were unable to accept *X. fornicator* as a valid species, though Beeson considered the retention of the name in subspecific rank to be desirable on biological evidence. Beeson (1941) stated that in north-east and north-west India and in Indo-China the tea bush is rarely attacked by *X. fornicatus*, although the borer is abundant in other hosts in the same locality, and there is no trace of the *fornicator* characters. In Ceylon (Gadd, 1946) experiments have demonstrated that the beetle from castor will bore into tea stems and the beetle from tea into castor stems, but whether the host plants are normally interchangeable in nature seems doubtful. Nor, by any means, do the beetles from tea always show *fornicator* characters; they are more often indistinguishable from castor beetles. For this reason the specific name *fornicatus* will be used here throughout to avoid any implication that galleries in tea stems had been made by beetles with *fornicator* characters.

The shape and size of galleries vary to some extent with the size of the branch in which they are made. Tea stems about half an inch in diameter and less seem to be preferred, whereas castor stems are usually much thicker when attacked. Galleries are made by females alone without any assistance from males. Each starts with a straight entrance gallery of variable length running radially into the stem. In small tea stems the entrance gallery stops at the pith, along which a straight longitudinal gallery is then made. More frequently, especially in thicker stems, the entrance gallery terminates in the wood near the cambium and the branch

galleries are circular, running parallel with the outer surface of the stem, often very close to the cambium yet not damaging it. All galleries are communal, there being no special brood cells or chambers. Eggs are usually found near the gallery ends, often in small heaps of five or six, but larvae, pupae and adults may be located in any part of a gallery.

Ambrosia can be seen as a fine, white, frost-like dust on the gallery wall, particularly where young larvae are feeding. It is not usually visible on the dark-stained walls of old galleries; nor does it ever occur in such quantity as to block the passage. There is no carefully prepared bed or layer of chips and excreta for the fungus to develop on, as mentioned by Imms (1934, p. 531) in his short general account of ambrosia, nor can two superimposed fungal layers be distinguished as described by Trotter (1934) from galleries made by an unnamed beetle in branches of living *Brownea grandiceps*.

Sections show that the fungus consists of a thin surface layer from which arise numerous short, erect, unbranched, septate conidiophores, at the ends of which are solitary club-shaped spores, aseptate at first but with several (up to five) transverse septa later (Pl. I, fig. 1). This fungus belongs to the genus *Monacrosporium*. Amongst the conidiophores, close to the gallery walls, a few globose cells about 30μ in diameter have been observed in tea stems, but not in castor. When stained, these globose cells each contain what appears to be a two-celled body (Text-figs. 1, 2). The nature of these cells is not understood and they do not occur in pure cultures of the *Monacrosporium*. In galleries in castor the conidiophores are somewhat more septate and the spores shorter and broader, but in other respects the fungi appear alike. Spores from galleries in tea (Text-figs. 3-5) range from $34-51 \times 10.5-13\mu$, while those from castor (Text-figs. 11, 12) range from $25-37 \times 11-15.5\mu$. Mean measurements of fifty spores were $40 \times 11.5\mu$ from tea, and $32 \times 13\mu$ from castor.

Speyer (1918), in a short statement on the fungi from shot-hole borer galleries in tea stems, wrote: 'Observations on the fungus upon which the larvae of shot-hole borers feed show that two fungi are generally present in healthy galleries. These have been identified by Mr Petch as *Monacrosporium* and a conidial ambrosia fungus. The spores of the former appear in the gallery about seven days after the beetle has entered the branch. It is known that the conidial stage of some ambrosia fungi are modified stages of fungi which grow free, on certain media, in a totally different form; there is therefore a possibility, though a remote one, that *Monacrosporium* is the free-living phase of the ambrosia grown by shot-hole borer.' In a later publication (1923) he gave another description: 'The ambrosia mycelium grown by *X. formicatus* consists of comparatively long, sparsely septate, narrow hyphae; curiously enough, the rounded conidial bodies characteristic of other ambrosia fungi have not been observed. In addition, spores of *Monacrosporium* are constantly found in the tunnels when this insect is excavating the gallery, and this fungus occurs also amongst the ambrosia hyphae.'

Speyer was evidently of the opinion that two fungi occur in the galleries, though how they can be distinguished in the absence of 'rounded conidial

bodies characteristic of other ambrosia fungi' is not apparent. Whether the globose cells amongst the conidiophores previously referred to in galleries in tea belong to a distinct fungus has not been determined, and they have not been observed in cultures of *Monacrosporium*. The available evidence indicates, however, that they are of no vital importance in insect nutrition.

If by the term ambrosia is meant the actual food of beetle larvae, then the *Monacrosporium* spores are ambrosia. The spores can be found in considerable numbers in the anterior gut of larvae freshly removed from galleries, and newly hatched larvae have been brought through all stages to pupation on pure *Monacrosporium* cultures derived from castor galleries in tea and castor. Nothing other than the fungus appears essential for their growth.

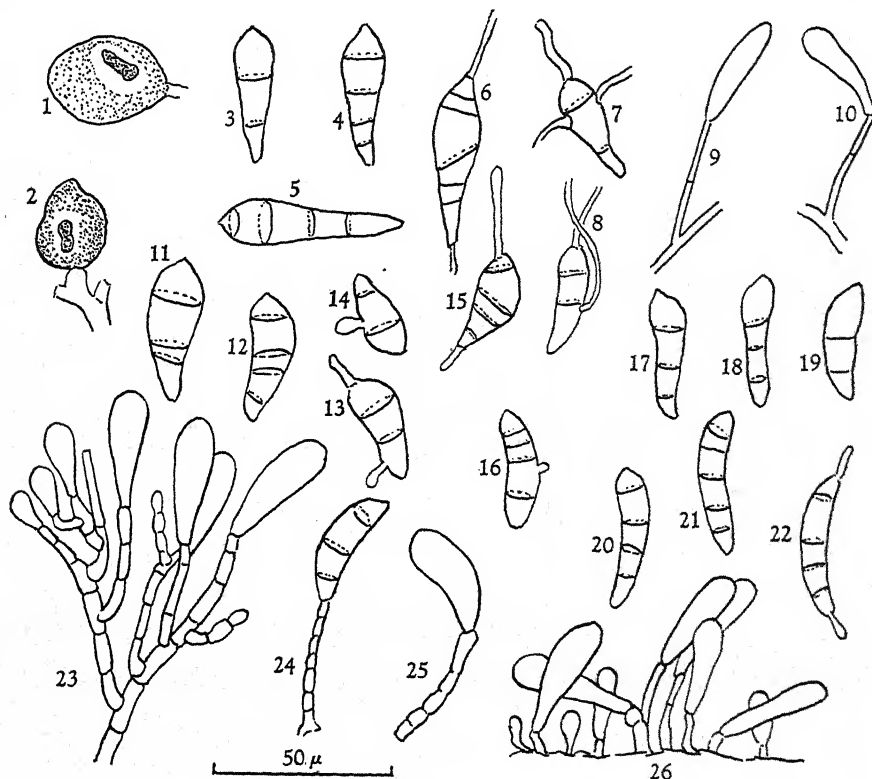
Single-spore cultures were easily obtained by plating spores from freshly opened galleries in tea or castor stems. The spores germinate rapidly, aseptate spores becoming septate and forming germ tubes within four hours. Germ tubes are normally produced at the apical and basal cells though they may arise from any cell (Text-figs. 6-8, 13-16). The fungus grew well on both malt agar and Waksman's agar without acid (Waksman, 1927, p. 19) at room temperature at the St Coombs Laboratory (64-76° F.). These were the only culture media tested, but it is probable that others would be equally suitable.

The cultures obtained from spores in galleries in tea were easily distinguished from those obtained from castor by their slower growth and greater colour development. At 26° C. cultures from tea, on plates, grew at an average rate of rather more than 5 mm. per day, whereas the castor cultures grew almost 9 mm. per day. Castor cultures were distinctly zoned (Pl. I, fig. 3) and had regular smooth edges, whereas tea cultures were less distinctly zoned with broken, rugged edges, and were markedly coloured (Pl. I, fig. 2). In tubes, the aerial mycelium of castor cultures was more cotton-woolly than those from tea, which had a looser and shorter mycelium. The colour change in plate cultures from tea became noticeable about the fourth day when the aerial mycelium near the centre of the colony became flesh coloured. Later the colour deepened to salmon, but the growing edge remained white. This colour development was not noticeable in tube cultures, nor in any cultures from castor. The agar of tea cultures, particularly slants, becomes deeply stained, dark vinaceous, near Corinthian purple (Ridgway, pl. 38), whereas in castor cultures the colour never attained a similar depth; it approximated Daphne red (Ridgway, pl. 38).

It may be appropriate to mention here that the wood adjacent to galleries in tea stems is usually stained dark purple (Speyer, 1922), though some variation occurs both in the colour and amount of it. The wood around galleries in castor is, however, rarely coloured. These observations support Verrall's (1943) statement that the stain around beetle tunnels is caused by the ambrosia fungi, which may easily be isolated from such wood. He attributed the intensification of colour to reactions of these fungi with insect secretions and other organisms, but in the writers'

opinion it may be due largely to the strain of the ambrosia carried by the beetles.

In microscopic detail very little difference was to be observed between the two cultures. The spores are normally produced on short unbranched



Text-figs. 1-26. *Monacosporium ambrosium* n.sp.

Text-figs. 1, 2. Globose bodies from galleries in tea stem.

Text-figs. 3-5. Mature spores from tea.

Text-figs. 6-8. Germinating spores from tea.

Text-figs. 9, 10. Immature spores and conidiophores from culture (tea).

Text-figs. 11, 12. Mature spores from castor.

Text-figs. 13-16. Germinating spores from castor.

Text-figs. 17-19. Mature spores from culture (tea).

Text-figs. 20, 21. Mature spores from culture (castor).

Text-fig. 22. Germinating spore from castor culture.

Text-fig. 23. Fragment from culture on which larvae had fed, showing branched conidiophores and immature spores.

Text-figs. 24, 25. Spores and conidiophores from castor gallery.

Text-fig. 26. Immature spores in tea gallery.

conidiophores, though in tubes in which larvae had fed branched conidiophores were encountered, each branch terminating with a solitary conidium (Text-fig. 23). The conidiophores are very variable in length, usually much longer and less septate than those observed in galleries. Spores varied somewhat in shape, but were generally clavate with 2-5 septa.

The spores from tea were not noticeably larger than those from castor, though fifty measurements of each gave the following results: tea $28-43 \times 8-12 \mu$ (mean $36 \times 9.5 \mu$); castor $22-40 \times 7-10.5 \mu$ (mean $33 \times 8.5 \mu$).

Spore production was markedly stimulated by removing aerial mycelium with a sterile bent needle. After twenty-four hours a large number of small pustules of spores appeared on the agar surface. Aerial mycelium did not again grow from the cleared surface, but the pustules or globular masses of spores increased in size (Pl. I, fig. 4). Cultures from tea and from castor behaved alike in this respect. The same thing probably occurs in the galleries. The larvae feed mainly, if not solely, on spores, as spores alone have been found in the gut of larvae examined. Their feeding evidently stimulates spore production, for it is in those parts of a gallery where larvae are feeding that spores can be found in large numbers.

In feeding experiments larvae hatched from eggs on damp blotting paper have been transferred to tea and castor cultures. Larvae from both sources fed readily on both cultures, and it appeared immaterial whether the tea or castor ambrosia was used as food supply for either beetle. Larvae were successfully brought to the pupal stage on both cultures.

Experiments clearly demonstrated that the food of *Xyleborus fornicatus* is the fungus *Monacrosporium* described. How the parent beetle carries it from the original gallery and plants it in her new gallery is not known. Several hypotheses have been advanced, but they need not be considered here. The importance of the fungus in the insect's economy, and the amount and nature of the work to be done before it can be planted in a suitable place for growth, seem to rule out the possibility that transfer is entirely accidental. But whether the transfer is accidental or due to instinctive actions, there can be little opportunity for the intermixing of the fungi carried by different families. It would not be surprising therefore, if numerous strains of the fungus exist, differing from one another in minor characters, such as colour development, determinable in comparable artificial culture. For this reason we regard the differences observed in culture between the two strains used in these studies as of minor importance.

So far as we are aware, this fungus has not been described previously; nor do we know of another ambrosia fungus belonging to the genus *Monacrosporium*. We therefore propose for it the name *Monacrosporium ambrosium*.

***Monacrosporium ambrosium* n.sp.**

The ambrosia fungus of the beetle *Xyleborus fornicatus* Eich. Vegetative hyphae in the wood adjacent to the galleries and thinly lining the gallery walls, thin, hyaline, septate and branched. Conidiophores produced on the gallery walls, crowded, erect, septate, normally unbranched, rarely exceeding the spore in length. Spores solitary, terminal, hyaline, clavate, non-septate at first, with rounded apex, later and before germination becoming 2-5 septate and with a bluntly pointed apex, $25-51 \times 10.5-15.5 \mu$.

Habitat. In galleries of *Xyleborus fornicatus* Eich. in *Camellia sinensis* (tea), *Ricinus communis* (castor-oil tree) and other stems invaded by the beetle.

Hyphae steriles in ligno contiguo, etiam in parietibus internis cuniculorum effusae, tenues, hyalinae, septatae, ramosae. Conidiophora in cuniculis efformata, dense congregata, erecta, septata, plerumque haud ramosa, longitudine rare sporam excedentia, apice monospora. Conidia hyalina, clavata, primo continua apice rotundata, demum ante germinationem 2-5 septata, in apicem obtusum angustata, $25\text{--}51 \times 10\text{--}5\text{--}15\text{--}5\mu$.

Hab. in cuniculis *Xylebori fornicati* Eich., in caulibus *Camelliae sinensis*, *Ricini communis* et arborum aliarum.

We are indebted to Miss E. M. Wakefield, M.A., F.L.S., of the Herbarium, Royal Botanic Gardens, Kew, for the Latin diagnosis.

SUMMARY

The fungus commonly associated with the ambrosia beetle *Xyleborus fornicatus* Eich., the shot-hole borer of tea and other plants, is described as new, and named *Monacrosporium ambrosium*. This fungus is undoubtedly the main, if not the sole, food of the beetle, as larvae have been brought from the egg to pupation on cultures of the fungus.

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EXPLANATION OF PLATE I

- Fig. 1. Section through gallery in tea stem (pith) showing spores. $\times 280$.
 Fig. 2. Culture on Waksman's agar 8 days old, tea strain. $\times \frac{1}{2}$.
 Fig. 3. Culture on Waksman's agar 8 days old, castor strain. $\times \frac{1}{2}$.
 Fig. 4. Spore pustules produced after removing aerial mycelium from culture. $\times 30$.

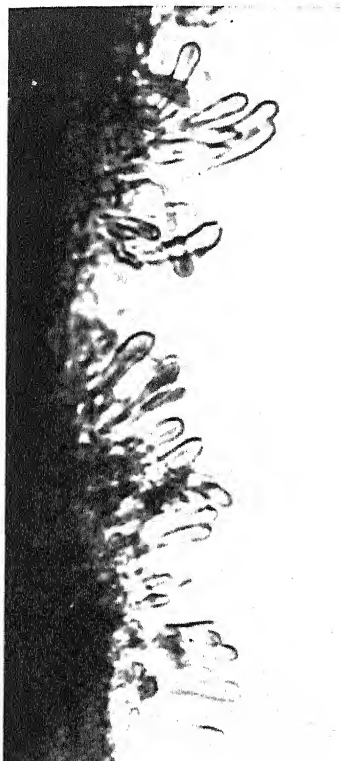


Fig. 1

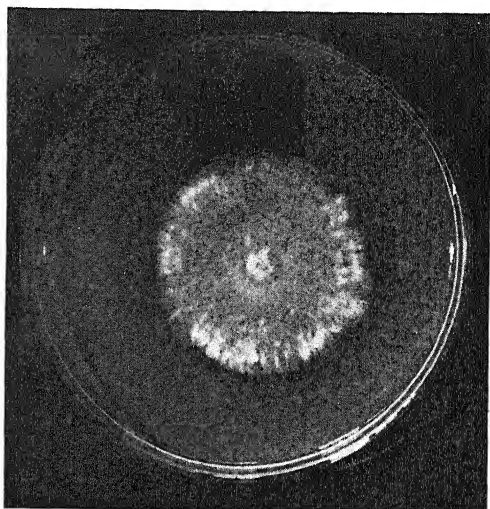


Fig. 2

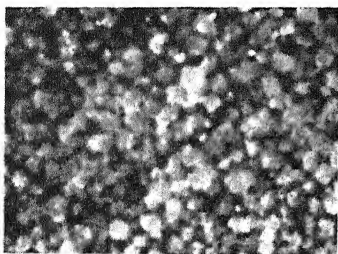


Fig. 4

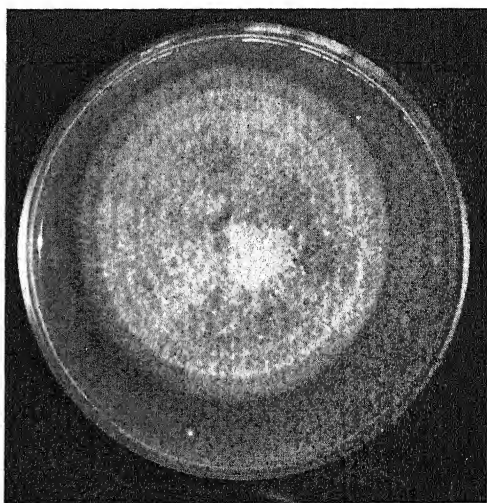


Fig. 3

A REVISION OF CEYLON *MARASMII*

By T. PETCH

(With Plates II-IV)

In their general account of the fungi of Ceylon (*J. Linn. Soc.* xiv, 31), Berkeley and Broome wrote '*Marasmii* and *Lentini* are, as might be expected, abundant', and in their systematic list they enumerated forty-four species of *Marasmius*, thirty-five of them new species. Unfortunately, only thirteen of these were illustrated in the series of paintings of agarics, sent with specimens by Thwaites and now at Peradeniya, from which Berkeley and Broome described most of their Ceylon species. There are also at Peradeniya specimens of Ceylon fungi which were erroneously supposed to have been named by Berkeley and Broome, cotypes in fact, but a later examination of some Thwaites correspondence showed that they had not been seen by them. As with other cryptogams, Thwaites divided each of his gatherings into two parts, one of which was sent to Berkeley and Broome, while the other was retained at Peradeniya, mounted on paper duly numbered, the names being added later after the publication of the 'Fungi of Ceylon'.

Thwaites collected his specimens over a fairly long period, and he placed under the same number those he thought were the same species. Naturally in some instances he was mistaken, and Berkeley and Broome divided up his specimens if they thought that was so. For example, Thwaites's no. 101 was collected on four dates ranging from November 1867 to September 1868, and Berkeley and Broome divided it into four *Marasmii* and a *Collybia*. But there was only one figure, and one can only surmise that the other species resembled it sufficiently closely to make Thwaites think that they were the same. It proved impossible to sort out these and similar mixtures from the specimens at Peradeniya, and the revision of the Ceylon *Marasmii* had to be postponed until Berkeley's specimens in Herb. Kew. and Broome's specimens in Herb. Mus. Brit. (not always the same) could be examined. Specimens were collected, described, and tentatively named, and during my home leave in 1911 and again in 1915, some progress was made in their determination, but with the expansion of the work of the mycological division this project ultimately lapsed.

The following include redescriptions of most of Berkeley and Broome's Ceylon species. The regions covered were practically those in which Thwaites collected his mycological specimens, but even these have not been exhausted. The low country, in both the wet and the dry zones, has yet to be investigated.

Marasmius nephelodes (B. & Br.) Petch, *Ann. Perad.* iv, 403; *Agaricus* (*Collybia*) *nephelodes* B. & Br., *Fungi of Ceylon*, no. 105; *Marasmius ochraceus* B. & Br., *Fungi of Ceylon*, no. 355.

Pileus broadly convex, centre even or irregularly depressed, reddish brown in the centre, ochraceous elsewhere, sometimes feebly zoned,

margin sometimes whitish, fleshy, smooth, slightly hoary when young, shining, 2-4 cm. diameter, flesh white, becoming reddish when cut; stalk 4-5.5 cm. long, 3-4 mm. diameter, nearly equal, white, sometimes longitudinally streaked ochraceous, becoming reddish or ochraceous when handled, pruinose or minutely tomentose, tough, hollow, base tomentose; gills pallid, distant, free or slightly adnexed, abruptly truncate behind; spores white, narrow oval, $9-13 \times 4 \mu$. On the ground among grass, solitary or in groups. Frequent on the lawns at Peradeniya (Pl. II, fig. 1).

Gardner's painting no. 70, referred by Berkeley to *Hygrophorus obruenseus* Fr., resembles this species, but as it was said to grow on the ground in woods it may be something else.

Marasmius calvus B. & Br., Fungi of Ceylon, no. 354.

Pileus up to 4.5 cm. diameter, hemispherical then broadly convex, sometimes slightly umbonate, fawn-coloured to ashy, bay brown in the centre, minutely pruinose, irregularly radially striate, becoming sodden and dark brown at the margin and along the striae, flesh white, thin; stalk up to 8 cm. long, 4 mm. diameter, white, longitudinally striate, often twisted, glabrous, white tomentose at the base, brittle, stuffed then hollow, brown internally; gills pallid, broad, distant, rounded behind, adnexed. On the ground among dead leaves. No. 4115, Hakgala, 28 September 1914 (Pl. I, fig. 8).

Berkeley and Broome described this species as 'umber, elegantly varied with radiating lines', and the gills as 'sometimes ventricose, as in the more beautifully painted specimens'. Thwaites's no. 766, however, was a mixture, both as regards specimens and paintings, and the figure elegantly varied with radiating lines is of a young specimen of *M. rivulosus*.

Marasmius purpureo-griseus Petch, *n.sp.*

Fasciculate. Pileus broadly convex, purple grey, paler towards the margin, not sulcate, minutely radially silky, about 1.5 cm. diameter, margin incurved, flesh white, thin; stalk up to 4 cm. long, 1.5 mm. diameter, brownish white, shining, cartilaginous, stuffed then hollow, fistulose; gills crowded, white or cream-coloured, broad, adnate or sinuato-adnate, edge straight. On dead wood, attached by white mycelium. No. 5736, Henaratgoda, 25 June 1918. The specimen became rather dry, before the painting could be made (Pl. III, fig. 7).

Marasmius multijugus (B. & Br.) Petch, in *Trans. Brit. mycol. Soc.* xxvii, 138; *A. (Collybia) multijugus* B. & Br., Fungi of Ceylon, no. 100.

Usually densely caespitose, sometimes connate at the base or up to half the height; pileus conico-campanulate, apex rounded, margin recurved when old, or convex or almost plane, centre sometimes depressed or almost umbilicate, up to 5 cm. diameter, ashy to red brown, glabrous when moist, innately silky when dry, irregularly plicate half-way to the centre, flesh very thin; stalk up to 10 cm. long, 7 mm. diameter, connate at the base, sometimes forking, often flattened and twisted, white, smooth or minutely

pruinose, equal, hollow, cartilaginous; gills pallid, becoming brown or liver-coloured from the edge upwards, distant, equal, rather broad, rounded behind, adnate or almost free, interstices veined; spores white, narrow oval, inequilateral, or somewhat attenuated to the apiculus, apiculus prominent curved, $6-9 \times 3-4 \mu$. Smell resembles that of *M. oreades*. On the ground, often with coarse rooting mycelium. Peradeniya, 6 April 1907; 30 June 1908; no. 6526, 1 May 1921 (Pl. III, fig. 15).

Marasmius leucophaeus (B. & Br.) Petch, in *Trans. Brit. mycol. Soc.* xxvii, 138; *A. (Collybia) leucophaeus* B. & Br., *Fungi of Ceylon*, no. 113; *Marasmius cornicolor* B. & Br., *Fungi of Ceylon*, no. 361.

Generally densely caespitose, sometimes scattered. Pileus usually 2-3.5 cm. diameter, plane, margin often repand, feebly striate in wet weather, centre even or depressed or umbilicate, or broadly convex, up to 5.5 cm. diameter, irregularly plicato-striate almost to the centre, deep purple brown, sometimes becoming paler outwards, often with an abruptly paler margin on small specimens and sometimes with a pale central spot over the stalk, appearing glabrous but covered with minute adpressed hairs, drying to ashy brown and minutely hoary, cartilaginous, thin, flesh purple brown; stalk up to 5 cm. long, 1-2 mm. diameter, dark purple brown when moist, ashy brown when dry, equal or slightly attenuated upwards, glabrous or minutely tomentose, often with a white tomentose ring at the apex, stuffed then hollow, often connate, base sometimes tomentose; gills narrow and crowded on small specimens, rather broad and subdistant on larger, adnate to the expanded apex of the stalk, pallid, becoming brown from above downwards, often retaining a pale edge; spores white, narrow oval, $6-10 \times 3-4 \mu$. On the ground among dead leaves, etc. Common at Peradeniya (Pl. III, fig. 2).

A form occurs on the rough bark of living trees, e.g. jak, which appears very different, except during heavy rains, when it assumes the normal form. It is usually scattered, pileus at first hemispherical, then plane, up to 1 cm. diameter, grey, purple grey, or bluish grey, hoary with adpressed fibrils and arid-looking. This form is no. 3265, 13 December 1911; no. 4172, 11 October 1914; no. 4206, 25 October 1914, all on jak trees, Peradeniya.

The specimens in Thwaites's no. 204, noted by Berkeley and Broome as dull reddish purple to fuscous, and assigned to *M. Wynnei* var. *auricolor* in *Fungi of Ceylon*, no. 353, are *M. leucophaeus*.

Marasmius rivulosus B. & Br., *Fungi of Ceylon*, no. 372.

Pileus campanulate to broadly convex, broadly umbonate, often depressed round the umbo, radially corrugated almost to the umbo, pale brown or tan, the colour varying with age and weather conditions, sometimes dark brown in the centre, ashy when dry, glabrous, about 4 cm. diameter but sometimes up to 10 cm., flesh white, thin except over the stalk; stalk up to 9 cm. long, 3 mm. diameter, base slightly expanded, longitudinally striate, at first smooth and shining, becoming finely white

tomentose, pallid then purple brown, fibrous in wet weather, subcartilaginous when dry, stuffed then hollow, internally brown, often excentric; gills white or pinkish, becoming brown, moderately crowded, broad near the stalk, elsewhere narrow, arcuate, adnate or adnato-decurrent, connected by veins; spores white with a yellow tinge, varying from oval, $6 \times 4 \mu$, to clavate or narrow oval with a thick excentric apiculus, $10-13 \times 5 \mu$, in the same spore print. On decaying stumps or on a felted mycelium on chips of wood, scattered or clustered; stalks usually excentric when growing on stumps. Common at Peradeniya (Pl. II, fig. 2). Young specimens are sometimes purple brown at first, the colour changing to pale brown first in the centre, leaving the margin darker brown or brown in the furrows.

Specimens on a living palm stem (*Wallichia*), no. 6626, 12 June 1923, and on coir in orchid pots, no. 6762 a, 19 June 1924, are more delicate and subpellucid, but otherwise the same.

***Marasmius rufo-ochraceus* Petch, n.sp.**

Fasciculate or scattered. Pileus broadly convex to almost plane and irregularly undulating, up to 3.5 cm. diameter, red brown in the centre, becoming ochraceous or pallid outwards, or wholly ochraceous when dry, irregularly radially grooved, glabrous, thin, cartilaginous; stalk up to 3 cm. long, usually compressed, up to 3 mm. broad, cartilaginous, red brown, becoming paler upwards, glabrous or very minutely tomentose, stuffed then hollow; gills moderately distant, slightly ventricose, adnate, pallid becoming reddish brown, interstices strongly veined when old; spores white, clavate, $10-14 \times 5-6 \mu$. On dead wood, Hakgala, no. 5583, 31 December 1917; no. 5603, December 1917; no. 6653, 7 September 1923.

Marasmius congregatus Mont., Guy. no. 307; *Cantharellus elegans* B. & Br., Fungi of Ceylon, no. 346; *Marasmius pellucidus* B. & Br., Fungi of Ceylon, no. 359.

In dense clusters among dead leaves or on rotten wood, with copious white rooting mycelium. Pileus frequently angularly campanulate at first, i.e. with a flat top and more or less perpendicular sides, then broadly campanulate, rarely plane, usually umbilicate, rather closely radially rivulose up to the centre, glabrous, translucent, papyraceous but tough, margin undulating, often repand, generally about 4 cm. diameter but sometimes up to 9 cm., white or yellowish; stalk up to 9 cm. long, 2-3 mm. diameter, rigid, cartilaginous, hollow, straight or twisted, glabrous, equal or expanding upwards, dark purple brown at the base, paler upwards and white at the apex, becoming entirely purple brown; gills white, usually narrow, about 1 mm. broad, but sometimes up to 4 mm., arcuate, forking, adnate to the expanded apex of the stalk, edge rather acute; spores white, clavate, $6-8 \times 3 \mu$. Common at Peradeniya (Pl. III, fig. 1).

Berkeley and Broome's specimens of *Cantharellus elegans* were small examples; after the description they added '*Marasmius congregatus* Mont.'. Saccardo interpreted that as '*huc spectat M. congregatus*'. Evidently Berkeley and Broome regarded the latter name as a synonym.

Marasmius crispatus B. & Br., Fungi of Ceylon, no. 357.

Clustered or scattered, among dead leaves. Pileus up to 7 cm. diameter, broadly convex, then plane, or repand and undulating, centre umbilicate, irregularly radially plicate almost to the centre, thin, tough, at first pallid grey brown, becoming buff on drying, glabrous, appearing cartilaginous when moist, but innately fibrillose when dry; stalk up to 9 cm. long, 4 mm. diameter, often compressed and up to 7 mm. broad, equal, expanding at the apex, cartilaginous, stuffed then hollow, dull, minutely powdered at first, becoming minutely tomentose, clothed with white tomentum at the base, with a mealy or minutely tomentose zone at the apex, coloured as the pileus at first, becoming purple brown from the base upwards; gills distant, arcuate, narrow, up to 4 mm. broad, sometimes forked, attenuated outwards, rounded behind and adnate to the expanded apex of the stalk, coloured as the pileus; spores white, oval, inequilateral, $8-10 \times 4 \mu$. No. 4239, Hakgala, 30 October 1914; no. 5235, Peradeniya, July 1917 (Pl. II, fig. 6).

In Herb. Peradeniya, there are two species in the specimens and paintings marked no. 766, *M. calvus*. That dated November 1868 is *M. crispatus*. Thwaites also sent specimens of the latter with *M. congregatus* in no. 38. It looks like a coarse *M. congregatus*.

Marasmius Caryotae (Berk.) Petch, *Ann. Perad.* iv, 403; *Heliumyces Caryotae* Berk., *Hooker's Lond. J. Bot.* (1847), p. 491.

Pileus 1-2.5 cm. diameter, rarely up to 5 cm., campanulate, occasionally depressed in the centre, then expanded with a recurved margin, deeply sulcate almost to the centre, glabrous, somewhat coriaceous, thin, pale yellow or greyish yellow, becoming ochraceous or pale brown when old, red brown when dried; stalk 4-8 cm. long, 1-2 mm. diameter, white becoming yellow, brown when old, rigid, hollow, almost glabrous, cartilaginous, tomentose at the base; gills distant, broad, somewhat ventricose, adnexed, rather thick, greyish yellow, brown when old; spores white, narrow oval or clavate, rather thick-walled, $20-25 \times 5 \mu$. On the ground among grass, usually in troops; common on the lawns at Peradeniya (Pl. II, fig. 3).

Marasmius hypochroides B. & Br., Fungi of Ceylon, no. 356.

Pileus up to 3 cm. diameter, broadly campanulate, margin irregular in expanded specimens, rather pale red brown or olive brown, very thin but tough, not sulcate, cells of the pellicle crowned with close-set conical spines up to 10μ long; stalk cartilaginous, hollow, fistulose, terete, 2 mm. diameter, or flattened, up to 4 mm. broad, equal or attenuated upwards or expanded upwards, glabrous, red brown below, yellow brown above; gills white, sometimes yellowish, distant, ventricose and up to 6 mm. broad in large specimens, free, interstices veined; spores white, obliquely oval, $8-13 \times 4-6 \mu$. Among dead leaves, etc. Peradeniya, no. 4208, 25 October 1914; no. 4244, 4 November 1914; no. 4372, 13 December 1914 (Pl. IV, figs. 10, 11).

Berkeley and Broome described the pileus as deeply sulcate; it has that

appearance in the dried specimens, because of the tenuity of the pileus and the thickness of the gills, but fresh specimens are even, becoming sulcato-striate when collapsing.

Marasmius brunneostriatus Petch, n.sp.

Pileus campanulate, then almost plane, obtusely umbonate, up to 2 cm. diameter, rufous, centre darker brown, margin paler, yellow brown, radially sulcate, deeper coloured in the sulcae, minutely rugose, margin often repand; stalk up to 2 cm. long, 1 mm. diameter, expanded at the apex, cartilaginous, red brown, pruinose or minutely tomentose, base tomentose, arising from a thin stratum of white mycelium; gills pale ochraceous, distant, rather thick, narrow, equal, adnate; spores white, clavate or oval, $5-9 \times 3-4 \mu$. On dead leaves and twigs. No. 4116, Hakgala, 29 September 1914 (Pl. II, fig. 7).

Marasmius fulviceps Berk., *Hooker's Lond. J. Bot.* (1847), p. 490; *Marasmius nummularius* B. & Br., *Fungi of Ceylon*, no. 351.

Pileus hemispherical, then broadly convex or almost plane, pale yellow or pale ochraceous, deeper ochraceous in the centre, or yellow brown, or sometimes deep brown, up to 1.5 cm. diameter, slightly wrinkled in the centre, radially striate elsewhere, glabrous; stalk up to 4 cm. long, 0.75 mm. diameter, blackish brown at the base, then red brown, yellow brown or white at the apex, cartilaginous, hispid, strigose at the base; gills crowded, narrow, white then pale ochraceous, adnate, the gill tissue continued from gill to gill round the apex of the stem; spores white, narrow oval, inequilateral, $10-12 \times 4 \mu$. On decaying leaves and twigs, scattered or clustered, arising from a sheet of tawny mycelium, frequently with innate strands radiating from the base of the stalk. Peradeniya, no. 2903, 9 August 1909; no. 3505, 14 July 1912 (Pl. IV, fig. 6).

This species was sent from Ceylon by Gardner, with a figure. The Thwaites specimen referred to it by Berkeley and Broome (Thw. 807*) is *M. haematocephalus*.

Marasmius pallidorubens (B. & Br.) Petch, in *Trans. Brit. mycol. Soc.* xxvii, 1938; *A. (Mycena) pallido-rubens* B. & Br., *Fungi of Ceylon*, no. 119.

Pileus campanulate or broadly convex, obtusely umbonate or depressed in the centre, membranous, translucent in wet weather, up to 4 cm. diameter, pale lavender, purplish brown in the centre, or in dry weather wholly vinous, strigose in the centre, elsewhere covered with scattered small scales with red brown points, plicato-sulcate almost to the centre, margin slightly serrate with brown points, flesh thin; stalk up to 3 cm. long, 2.5 mm. diameter, equal or slightly attenuated upwards, colour of the pileus, becoming red brown, covered with minute red brown points, hollow, subtranslucent; gills distant, ventricose, sinuato-adnate or adnato-decurrent, lavender becoming purplish red, edge clothed with red brown points, interstices veined; spores white, subglobose, or somewhat pyriform with an apical apiculus, $8-9 \times 7-8 \mu$. The pileus and gills turn rather dark red when bruised; stains paper red. On dead wood. Pera-

deniya, no. 4277, 7 November 1914; no. 4382, 19 December 1914 (Pl. II, fig. 5).

After the description, Berkeley and Broome stated 'no. 937 is possibly the same species. Spores .0003 by .00025, echinulate'. The later statement is entered in Saccardo for *Mycena pallido-rubens*, but no. 937 in Herb. Peradeniya is a different species.

Marasmius proximus B. & Br., Fungi of Ceylon, no. 368; *M. obscuratus* B. & Br., Fungi of Ceylon, no. 370, not of Petch in *Ann. Perad.* vi, 56.

Pileus at first hemispherical, then expanded, plane, or depressed in the centre with a decurved margin, sometimes with a broad convex umbo and a depressed ring round it, feebly sulcate almost to the centre when fresh, pale ochraceous, or ashy and brownish in the centre, about 1 cm. diameter, rugose, minutely scurfy when dry; stalk about 1.5 cm. long, 0.5 mm. diameter, red brown at the base, yellow brown above, becoming black brown, cartilaginous, minutely pruinose or tomentose, sometimes with a white tuft of hyphae at the base, especially when growing on dead leaves; gills adnate or adnato-decurrent, pallid then pale brown, somewhat distant, rather ventricose. On dead leaves and twigs, sometimes accompanied by a white glabrous film of mycelium. Peradeniya, no. 3359, January 1912; no. 4152, 11 October 1914; no. 4205, 24 October 1914; no. 6553, 30 October 1922. Henaratgoda, nos. 5905, 5906, 25 June 1918. The pileus and gills sometimes turn red brown when dried (Pl. II, fig. 9).

Berkeley and Broome cited Thwaites no. 93 in part for this species. The remainder of no. 93 was assigned to *Naucoria furfuracea* P., together with Thwaites no. 1182. The latter has been shown to be *Flammula dilepis* B. & Br. (*Ann. Perad.* iv, 53), and the remainder of no. 93 is *Marasmius proximus*. *Naucoria furfuracea* should be deleted from the Ceylon list. The type of *Marasmius proximus* in Herb. Kew. is marked 93 and 398. No. 398 was described as *Omphalia delicia* B. & Br.; I have not examined the type.

The specimens and figure of Thwaites no. 804, which Berkeley and Broome placed as a variety of *Marasmius subcinereus*, are *M. proximus*. *M. mutabilis* was also Thwaites no. 804 (not 204) but the note 'pale dun colour when fresh' refers to *M. proximus*, not to it. *M. obscuratus* B. & Br. was based on small specimens of *M. proximus*.

Marasmius hirtellus B. & Br., Fungi of Ceylon, no. 382.

Pileus at first broadly convex, then almost plane or with a decurved margin, centre depressed, often with a broad convex umbo and a depressed ring round it, feebly radially sulcate towards the margin when fresh, ashy or ashy brown, usually with a pink or purple tinge when fresh, sometimes with a pale central spot, surface of innate matted fibrils, appearing smooth or minutely lacunose, about 1 cm. diameter; stalk up to 2.5 cm. long, 0.75 mm. diameter, cartilaginous, hispid, red brown, becoming black brown from the base upwards; gills rather crowded, narrow, adnate, white or pallid, becoming pale brown; spores white, narrow oval, somewhat clavate, $6-8 \times 3 \mu$. On dead leaves and twigs, sometimes accompanied by a white glabrous film of mycelium. Fairly common at Peradeniya;

no. 4152, 11 October 1914; no. 4294, November 1914; no. 4300, November 1914; no. 5807, 27 October 1918; no. 5808, 28 October 1918 (Pl. II, fig. 4, and Pl. III, fig. 13).

Notwithstanding the figures, it is difficult to separate this species always from *M. proximus*. As a rule, the latter has broader and more distant gills.

Marasmius mutabilis B. & Br., Fungi of Ceylon, no. 367; *M. eximius* B. & Br., Fungi of Ceylon, no. 371.

Pileus infundibuliform, outer half sometimes almost plane, up to 2 cm. diameter, pale brown to reddish brown, glabrous, radially streaked with innate darker fibrils especially in the funnel, even, becoming radially sulcate, tough, thin, total height 1.5–2 cm.; stalk up to 1.4 cm. long, 1.5 mm. diameter, expanded upwards, at first purple brown at the base, white above, becoming dark purple brown, cartilaginous, minutely tomentose, usually with a rather compact whitish cushion at the base, faintly longitudinally striate; gills pallid, becoming brown when old, decurrent, rather distant, sometimes forked, arcuate, interstices veined; spores white, narrow oval, $8-9 \times 4 \mu$. On dead wood and sticks. Peradeniya, no. 2298, 12 August 1906; no. 4289, 11 November 1914.

This was part of Thwaites no. 804, not 204 as stated in the Fungi of Ceylon. Berkeley and Broome said it was analogous to *Cantharellus rubidus*. They probably meant *C. rabidus*, Fungi of Ceylon, no. 349, and Saccardo printed it as *rabidus* in the note to *M. mutabilis*.

The type of *M. eximius* is a large specimen of *M. mutabilis*. It is infundibuliform, with broad decurrent gills, and innate radial dark fibrils on the pileus.

***Marasmius senescens* Petch, n.sp.**

Pileus 1.5 cm. diameter, broadly convex, centre depressed, sometimes umbonate, even or irregularly plicato-sulcate, centre wrinkled, sordid grey with a paler margin, thin, centre slightly tomentose, elsewhere with a few scattered fibrils and here and there glistening particles; stalk 1 cm. long, 1.5 mm. diameter in the middle, expanding upwards, white or ashy, becoming black brown from the base upwards, compressed, striate, minutely longitudinally silky, cartilaginous; gills distant, adnate or adnato-decurrent, united behind over the stalk and separating, broad, slightly ventricose, rather thick, forked, pallid then brownish, interstices veined; spores white, narrow oval, somewhat pyriform, $7-10 \times 3-4 \mu$. On the ground. No. 4306, Peradeniya, 15 November 1914.

Marasmius subcinereus B. & Br., Fungi of Ceylon, no. 369.

Pileus convex, then plane, slightly depressed, or umbilicate, sometimes infundibuliform in wet weather, sulcate almost to the centre, thin, dark green when young, then greenish grey or greenish white, almost black in the centre, or grey in the centre, white on the outer half, blotched green, becoming greenish brown or pale greyish brown when old, up to 1.5 cm. diameter; stalk up to 2.5 cm. high, 0.5 mm. diameter, rigid, dull, bluish

black or black, pale towards the apex, hoary with minute white particles, solid, slightly thickened upwards, base either not thickened, or expanded into a disc up to 1.5 mm. diameter, or with a small tuft of white hyphae; gills white when young, then bluish or bluish grey, rather broad, distant, thick, adnate or slightly decurrent, interstices strongly veined; spores white, stellate, consisting of four broad-based triangular processes, each about 4μ long and $3-4\mu$ diameter at the base, the distance from point to point being $8-12\mu$. On young specimens, the pileus and gills turn blue to greenish black when bruised. On fallen branches and dead leaves. Peradeniya, not uncommon. No. 6627, 12 June 1923 (Pl. III, fig. 14).

A form with a pure white pileus and gills occurred on the trunks of living nutmeg trees at Peradeniya. Pileus up to 1.5 cm. broad, orbicular, convex or almost plane; stalk excentric, curved, up to 3 mm. long, 0.5 mm. diameter, expanding slightly upwards, greenish black, or black below, bluish above, pruinose; gills white, arcuate in convex pilei, ventricose in plane examples; colour change when bruised, and spores, as in the type. No. 6542, 22 September 1922; no. 6709, 25 December 1923 (Pl. III, fig. 5).

Marasmius corticigena B. & Br., Fungi of Ceylon, no. 388.

Pileus at first broadly convex, pale reddish brown in the centre, ashy or white towards the margin, margin even or faintly striate, minutely rugose; then expanded, up to 2.5 cm. diameter, broadly convex or plane, pale reddish brown, irregularly sulcato-striate over two-thirds the pileus, centre innately radially silky; stalk at first white, becoming brown from the base upwards, finally black brown, purple brown at the apex, expanding above, minutely tomentose, cartilaginous, base slightly tomentose, up to 2 cm. long, 0.8 mm. diameter in the middle; gills at first white, finally pale brown, subdistant, slightly ventricose, attenuated outwards, narrow, of four lengths, the longer adnate and united behind over the stalk, edges here and there tomentose with irregular, somewhat nodular hairs, up to $50 \times 8\mu$, sometimes encrusted at the apex, interstices veined; spores white, narrow oval or clavate, $8-12 \times 3.5-4\mu$. On living tree trunks. Peradeniya, no. 4370, 13 December 1914; no. 6486, 19 July 1922 (Pl. II, fig. 10).

Berkeley and Broome's specimens were quite immature, the pileus 3 mm. diameter, margin incurved, and the stalk 5 mm. long, brown to black. They show the tomentum on the gill edges.

Marasmius nivosus Berk., *Hooker's Lond. J. Bot.* (1856), p. 139.

Pileus at first broadly convex, then plane, even, or umbonate in the centre, becoming depressed or subumbilicate, or with a ring furrow surrounding the umbo, irregularly radially sulcate almost to the centre, white, pale ochraceous in the centre, or pale ochraceous with a pinkish tinge, becoming ashy on drying, coriaceous, 1-2 cm. diameter, margin irregularly crenate; stalk concolorous with the pileus, but purplish in very wet weather, up to 2 cm. long, 1 mm. diameter, equal, expanded slightly at the apex, cartilaginous, stuffed, glabrous or minutely pruinose; gills white, moderately crowded, arcuate, adnate or slightly decurrent. Among

grass. Peradeniya, no. 6316, 20 November 1921; no. 6552, 30 October 1922; no. 6624, 12 June 1923 (Pl. III, fig. 12).

The fungus described above agrees with the specimens, Thwaites no. 932, in the Peradeniya herbarium, identified by Berkeley and Broome, but not altogether with the original description.

Marasmius stypinus B. & Br., Fungi of Ceylon, no. 389.

Pileus hemispherical, up to 8 mm. diameter, sometimes expanded, broadly convex, up to 1.5 cm. diameter, even or obtusely umbonate or sometimes depressed in the centre, expanded specimens feebly radially sulcate, white, slightly ochraceous in the centre, pruinose, or minutely tomentose on unexpanded specimens, becoming minutely sprinkled with brown points or almost glabrous, brown when old; stalk at first white, subtranslucent, rather stout, up to 1.5 cm. long, 0.6 mm. diameter, becoming red brown from the base upwards and diminishing to 0.4 mm. diameter, finally entirely blackish brown, cartilaginous, dull, minutely fibrillose or pruinose; gills distant, white, becoming brown when old, adnate, arcuate, or somewhat ventricose on expanded specimens, edge serrate; spores white, $10-12 \times 4 \mu$, clavate, apiculus obtuse and sublateral, making the spore sometimes appear hooked at one end. On sticks and bamboos: remarkable for the persistence of its juvenile condition. Peradeniya, no. 2867, 4 July 1909; no. 2873, 18 July 1909; no. 2899, 5 August 1909; no. 4248, 4 November 1914 (Pl. IV, fig. 17).

Marasmius stypinoides Petch, n.sp.

Pileus white, greyish in the centre, broadly convex or almost plane, up to 5 mm. diameter, centre umbilicate, feebly radially sulcate, minutely rugose, margin crenate; stalk up to 8 mm. long, usually curved, 0.4 mm. diameter, at first white, turning black from the base upwards, shining, minutely powdered, longitudinally striate, expanded at the apex; gills white, crowded, rather ventricose, the longer adnate to the expanded apex of the stalk and separating as if collared, edge serrate. On dead bark on a fallen tree trunk. Hakgala, no. 4029, April 1914.

No. 4114, on a dead leaf, Hakgala, September 1914, is a similar species, but is umbonate. Unfortunately I have seen only one example.

Marasmius cineraceus Petch, n.sp.

Pileus infundibuliform, margin decurved, feebly radially sulcate, 9 mm. diameter, ashy, smooth, with a surface layer of interwoven hyphae; stalk black, with a white pruina, cartilaginous, 1 cm. long, 0.75 mm. diameter, equal, arising from a small circular glabrous disc; gills moderately crowded, white, sigmoid, broad, adnato-decurrent, margin crenate, interstices veined. On a dead leaf. Peradeniya, no. 5589, October 1918.

Marasmius Leveillianus (Berk.) Pat., *Bull. Soc. Mycol. Fr.* xxxiii (1917), 55; *Heliomyces Leveillianus* Berk., *Decades of Fungi*, no. 158; *Marasmius umbraculum* B. & Br., Fungi of Ceylon, no. 365.

Pileus up to 3.5 cm. diameter, at first hemispherical, becoming plane, umbonate, depressed round the umbo, radially sulcate, rigid when dry,

deep red brown, glabrous; stalk up to 8 cm. long, 0.5 mm. diameter, black brown, equal, expanding suddenly at the apex, rigid, horny, glabrous, hollow; gills distant, usually all the same length, free, truncate behind, white becoming yellow, margin sometimes red brown, interstices sometimes veined; spores white or faintly yellowish, narrow oval, $8-10 \times 3-4 \mu$. Gregarious, on dead stumps, bamboos, etc., rather common. Peradeniya, 18 June 1906; 15 July 1907; 15 July 1909, etc. Wariapolla, 6 December 1906 (Pl. IV, fig. 2).

Marasmius atrorubens Berk., *Hooker's Lond. J. Bot.* 1, 188.

Pileus campanulate at first, hispid with setae like those of the stalk but shorter, then broadly convex and glabrous or nearly so, 1 cm. diameter, deep red brown, somewhat mottled, margin faintly striate when fresh, grooved when dry, cells of the pellicle covered with short spines up to 5μ long; stalk up to 4.5 cm. long, 0.5 mm. diameter, horny, rigid, red brown, brown when dry, hispid with brown, rigid acute setae, up to 120μ long, $3-4 \mu$ diameter, apparently persistent; gills crowded, pallid then pale ochraceous, free. In groups among dead leaves, arising from yellowish strigose patches of mycelium. Peradeniya, no. 5176, 10 June 1917.

The above description refers to Ceylon specimens which appear to fit Berkeley's description. They have not yet been compared with the type from Cuba. The Ceylon specimens attributed by Berkeley and Broome to *Collybia stupparia* B. & C. are this species.

Marasmius florideus B. & Br., *Fungi of Ceylon*, no. 380.

Pileus campanulate or conico-campanulate, then expanded and margin repand, apex sometimes flattened, up to 2 cm. diameter, red brown, dark in the centre, becoming paler outwards, plicato-striate almost to the centre, thin but tough; stalk up to 5.5 cm. high, 1 mm. diameter, glabrous, horny, red-brown to yellow brown below, pale at the apex, becoming blackish brown from the base upwards, base strigose; gills cream-coloured to yellowish, edge red brown, ventricose, adnate, moderately distant, of four lengths. Among dead leaves. Peradeniya, no. 4207, 25 October 1914 (Pl. IV, fig. 3).

Marasmius confertus B. & Br., *Fungi of Ceylon*, no. 352; *M. chondripes* B. & Br., *Fungi of Ceylon*, no. 364; *M. hemibaphus* B. & Br., *Fungi of Ceylon*, no. 379.

Pileus hemispherical, then expanded, broadly convex or almost plane, reddish brown in the centre, elsewhere tawny or golden brown, centre even or slightly depressed, margin feebly sulcate, usually about 1.5 cm. diameter, exceptionally 3 cm., membranous, the cells of the pellicle bearing close-set conical spines up to 6μ long; stalk up to 3.5 cm. long, 0.5 mm. diameter, rigid, horny, shining, often flexuose, yellow brown, red brown at the base, white at the apex at first, attached by a tuft of tawny fibrils; gills crowded, yellow or yellow brown, shortly adnate, attenuated outwards, narrow; spores white, clavate, $11-13 \times 3 \mu$. Scattered or clustered, on the ground

among dead leaves and twigs. Peradeniya, no. 2408, 14 June 1907; no. 2870, 16 July 1909. Henaratgoda, no. 5904, 25 June 1918.

Berkeley and Broome gave the spores as subglobose, 6μ diameter. Their type specimen bears a few minutely warted globose spores about 4μ diameter, no doubt intrusive *Penicillium* or *Aspergillus*.

Marasmius hemibaphus was described as umbonate and sulcate, but the sulcae are chiefly the result of drying, and the pileus is not umbonate, but darker in the centre than on the outer half, a fact which perhaps suggested the name. There was no painting of this species. Thwaites no. 204, from which it was described, was a mixture, part of which was *Collybia leuco-phaea*, and the painting, no. 204, is of the latter species. *Marasmius chondripes*, also part of Thwaites no. 204, is a young *M. confertus*.

Marasmius haematocephalus Mont., *Syll. Crypt.* no. 351.

Pileus conico-campanulate or hemispherical, up to 7 mm. diameter, sometimes repand and up to 2 cm. diameter, plicato-sulcate almost to the centre, membranous, purple red or bluish purple or red brown; stalk hair-like, flexuose, usually 3-4 cm. long, 0.25-0.5 mm. diameter, horny, shining, black brown below, pale brown above, with a small tuft of white hyphae at the base; gills white, often tinged purple like the under side of the pileus, often with a red edge, free but close to the stalk or adnate to the swollen apex of the stalk, few, distant, ventricose, interstices veined when old; spores white, clavate (like an Indian club), $16-22 \times 3-4\mu$. On decaying leaves and twigs, gregarious. Common in mid and low country (Pl. IV, fig. 4).

No. 3510, Peradeniya, 21 July 1912, was dark greenish grey or olive, but otherwise did not differ from the typical purple red form.

Marasmius helvolus var. *brunneolus* B. & Br., *Fungi of Ceylon*, no. 375.

Pileus conico-campanulate or hemispherical, about 1 cm. diameter, 8 mm. high, brown in the centre, becoming yellow brown outwards, membranous, plicato-sulcate nearly to the centre or half-way, minutely velvety, the spines on the cells of the pellicle tending to be arranged in dots; stalk up to 4.5 cm. long, 0.5 mm. diameter, equal, glabrous, shining, at first pellucid, becoming brown from the base upwards, with a spreading tuft of white or tawny hyphae at the base; gills distant (about twelve), white, free, ventricose; spores white, narrow clavate, $16-19 \times 4\mu$. On dead branches and leaves. Peradeniya, no. 2904, 8 August 1909; no. 4204, 23 October 1914 (Pl. IV, fig. 13).

The specimens described above agree with those of Thwaites no. 752 at Kew and Peradeniya. Berkeley and Broome stated that the pileus and gills were brownish, but there was no figure. *M. helvolus* Berk., type, was described from Cuba.

*Marasmius coniatu*s B. & Br., *Fungi of Ceylon*, no. 358.

Pileus conico-campanulate, up to 4 mm. diameter and 3 mm. high, plicato-sulcate, olive brown in the centre, becoming brownish buff outwards, membranous, sprinkled with minute glistening particles, especially

in the furrows, cells of the pellicle bearing close-set cylindrical spines up to 6μ high; stalk black (brown when dry), shining, hair-like, up to 2.5 cm. long, 0.2 mm. diameter, pellucid at the apex, arising from a thin white layer of mycelium; gills free, distant, ascending, pallid, edge brown. On dead leaves and twigs. Peradeniya, no. 4221, 25 October 1914 (Pl. IV, fig. 1).

Marasmius subconiatius Petch, n.sp.

Pileus up to 5 mm. diameter, broadly convex, centre umbilicate, plicato-sulcate to the centre, dull reddish brown, sprinkled with minute hyaline particles, cells of the pellicle crowned with close-set conical spines; stalk up to 6 mm. long, stout, 0.4 mm. diameter, black brown, glabrous, cartilaginous; gills numerous (14), distant, cream-coloured, broad, lower edge straight or somewhat ventricose, broadly adnate. On bamboo. Peradeniya, no. 4295, 12 November 1914.

Looks like a small stout form of *M. coniatius*, but differs in the number and attachment of the gills, and the absence of a film of mycelium on the substratum.

Marasmius semipellucidus B. & Br., Fungi of Ceylon, no. 360.

Pileus conico-campanulate, sometimes expanding to almost plane, sometimes with a recurved margin, up to 1 cm. diameter, membranous, plicato-sulcate almost to the centre, pinkish brown; stalk usually about 3 cm. long, but sometimes up to 8.5 cm., 0.5 mm. diameter, at first light brown, becoming almost black at the base, horny, smooth, the base surrounded by a small cushion of hyphae; gills white, free, ventricose, distant (usually 12 to 16), sometimes with a brown or reddish edge; spores white, clavate, $14-22 \times 4-5\mu$. The whole pileus and gills have a pinkish tinge when moist. On decaying leaves and twigs. Peradeniya, nos. 2437, 2438, 16 June 1907; no. 4287, 9 November 1914; no. 4315, 20 November 1914 (Pl. IV, fig. 8).

Berkeley and Broome described the stalk as 'toto striato', but that is not evident on fresh specimens. They also stated that it is distinguished by the upper part of the stem being pale and pellucid, a feature which is common to all species of this class in their earlier stage.

Marasmius lateritius Petch, n.sp.

Pileus convex or conico-convex, even or obtusely umbonate, up to 6 mm. diameter, pinkish red or brick red, darker when old, often mottled with yellowish patches, margin not striate or plicate (except when old); stalk up to 2.5 cm. high, 1 mm. diameter, at first white, then yellow brown from the base upwards, horny, minutely hispid, strigose at the base; gills white, then yellow, not distant, rounded or truncate behind, attenuated outwards, free but close to the stem; spores white, clavate, $10-13 \times 3-4\mu$. On the ground among dead leaves. Peradeniya, no. 4375, 15-16 December 1914 (Pl. IV, fig. 5).

Marasmius albocapitatus Petch, n.sp.

Pileus pure white, hemispherical, up to 4 mm. diameter, minutely umbilicate, feebly sulcate; stalk up to 1.5 cm. long, 0.2 mm. diameter,

black brown, hair-like; gills white, narrow, ascending, adnate, edge obtuse; spores white, narrow oval, $8-10 \times 3 \mu$. The pileus and stalk bear long erect spreading hairs, not visible to the naked eye, yellow brown by transmitted light, acute, tapering, about 4μ diameter below, up to 0.35 mm. long, and the stalk bears in addition minute irregular thick-walled hairs, usually curved, up to $30 \times 6 \mu$. Cystidia on the edge of the gills flask-shaped, up to 34μ high, 12μ diameter below. On dead leaves. Hakgala, no. 4127, September 1914; no. 5294, April 1917 (Pl. IV, fig. 15).

***Marasmius micraster* Petch, n.sp.**

Pileus 3 mm. diameter, almost plane when moist, campanulate and radially plicate when dry, black brown to yellow brown, paler in the furrows, membranous, centre depressed and wrinkled, cells of the pellicle globose, about 16μ diameter, strongly verrucose on the outer half with yellow brown warts, pileus appearing minutely pruinose when magnified; stalk hair-like, black brown, glabrous, shining, about 1 cm. long, 0.2 mm. diameter; gills few (about ten), white or cream, ventricose, free but close to the stem, edge bears flask-shaped cystidia, up to 16μ high, with a truncate apex; spores white, oval, one end acute, $10-12 \times 4-5 \mu$. On decaying twigs. Peradeniya, no. 4195, 21 October 1914.

***Marasmius Thwaitesii* B. & Br., Fungi of Ceylon, no. 383.**

Pileus in dry weather cylindrical, $2-2.5$ mm. diameter, 3 mm. high, dark brown, covered with spiny clusters of hairs and plicate in longitudinal ridges; when moist, broadly campanulate or almost plane, up to 6 mm. diameter, plicato-sulcate, blackish brown in the centre, somewhat lighter brown along the tops of the ridges and pale brown in the furrows; the centre and the dark ridges retain the hair clusters for some time, but they ultimately disappear, first from the ridges and then from the centre; the ridges are produced beyond the margin of the pileus by a spinous tuft of hairs; stalk up to 2.5 cm. long, 0.25 mm. diameter, rigid, dark brown, almost white at the apex, rough; gills about twenty, moderately distant, yellowish white, edge brown distally, narrow, united behind by a very narrow collar. On sticks and decaying palm stems. Frequent at Peradeniya. No. 4353, 1 December 1914 (Pl. IV, fig. 9).

***Marasmius gordipes* Sacc. & Paol., *Mycetes Malacc.* p. 6, Pl. V, fig. 2.**

Pileus membranous, broadly convex, with or without an acute black umbo at the base of the umbilicus, sulcate to the centre, $3-5$ mm. diameter, red brown; stalk filiform, very long, up to 13 centimetres long, 0.3 mm. diameter, somewhat rigid, striate when dry, glabrous, shining, blackish brown, insititious; gills distant (up to 12), yellowish or ochraceous, sometimes with a reddish edge, comparatively broad, united behind into a collar which may fit closely round the stalk or be widely separated from it and shallow; spores white, narrow oval, somewhat clavate, $8-12 \times 4-5 \mu$. On decaying twigs and leaves on the ground. Peradeniya, no. 2902, 9 August 1909; no. 4235, 1 November 1914. Not a Horsehair Blight (Pl. IV, fig. 7).

Marasmius tubulatus Petch, n.sp.

Pileus cylindrico-campanulate, deeply umbilicate, radially sulcate to the centre, pruinose, membranous, up to 8 mm. diameter, pallid then brownish grey with a pale margin and a black spot at the base of the umbilicus; stalk up to 2 cm. long, 0.3 mm. diameter, blackish brown, horny, glabrous, shining, finely longitudinally striate; gills distant, white then pallid with a brownish grey edge, subtriangular, united behind into a tube, free from the stem, which descends almost to the level of the margin of the pileus, free edges arched; spores white, oval or clavate, $7-9 \times 3-4 \mu$. On dead leaves and twigs. Peradeniya, no. 4243, 1 November 1914; also 18 July 1909 (Pl. III, fig. 9).

Marasmius griseoviolaceus Petch, n.sp.

Pileus campanulate, up to 1 cm. diameter, umbilicate, plicato-sulcate, membranous, greyish or brownish violet or purplish brown, or almost black in the centre and blackish grey elsewhere, with or without a minute umbo at the base of the umbilicus, feebly rugose with minute black elevations when fresh; stalk up to 7 cm. long, 0.5 mm. diameter, attenuated upwards, rigid, horny, black, shining; gills white, distant (up to 14), arcuate or triangular, edge coloured as the pileus, united behind into a collar round the stem; spores white, oval, inequilateral, $8-11 \times 6 \mu$. Has a black repent rhizomorphic mycelium, 0.25 mm. diameter, and arises either from the rhizomorphs or from the host tissue. Peradeniya, at the base of clumps of Giant Bamboo (*Dendrocalamus giganteus*), no. 4238, 1 November 1914; on dead leaves; no. 4213, 25 October 1914 (Pl. IV, fig. 14).

Marasmius rotalis B. & Br., Fungi of Ceylon, no. 387; Petch in *Ann. Perad.* VI, 50.

Pileus 4-6 mm. diameter, hemispherical, umbilicate, generally with a minute umbo at the base of the umbilicus, minutely rugose, radially sulcate with from eight to eighteen grooves, yellow brown, greyish brown or ashy, membranous; stalk 2-4 cm. long, 0.2-0.5 mm. diameter, black, horny, filiform, shining; gills white or yellowish, distant, rather broad, lower edge almost horizontal, united behind into a collar round the stalk; spores white, narrow oval, $8-12 \times 3-4 \mu$. On dead leaves and twigs on the ground, with black, glabrous, cylindric rhizomorphic mycelium about 0.1 mm. diameter. Peradeniya and Hakgala, frequent.

The following colour varieties have been noted. Pileus orange red, gills orange, stalk brown, Hakgala, no. 3725, 23 May 1913. Pileus, gills and stalk orange, Hakgala, no. 4137, September 1914. Pileus greyish fawn, gills white, stalk black brown, Hakgala, no. 4129, 29 September 1914. Pileus olive brown, Hakgala, no. 4138, September 1914. Pileus white, umbo black and prominent, Hakgala, no. 5587, December 1917.

Marasmius equicrinis Muell., *J. Linn. Soc.* XVIII, 383; Petch in *Ann. Perad.* VI, 43.

Mycelium rhizomorphic, black, smooth, glabrous, cylindrical, about 0.1 mm. diameter, overrunning leaves and stems of living shrubs and trees

(Horse-hair Blight). Pilei arising laterally from the aerial mycelium, or from dead leaves and twigs on the ground.

Pileus up to 8 mm. diameter, hemispherical, often irregularly repand, umbilicate, membranous, radially sulcate, yellow brown to red brown, with a minute black umbo; stalk 2-10 mm. long, 0.1 mm. diameter, filiform, black, glabrous; gills few (up to eight), white, then cream or yellowish, distant, attenuated behind, united into a collar round the apex of the stalk; spores white, narrow oval, inequilateral, or clavate, $10-14 \times 4 \mu$. Cells of the pellicle (as in *M. rotalis*) crowned with close-set, blunt spines. Common in the wet low-country of Ceylon, up to an elevation of 1600 ft. (Pl. III, fig. 8).

Marasmius rigidichorda Petch, n.sp.; *M. obscuratus* Petch, non B. & Br., in *Ann. Perad.* vi, 56.

Mycelium rhizomorphic, dull black, rigid, 0.4-0.6 mm. diameter, overrunning the branches of jungle shrubs. Pilei produced on the aerial mycelium and on the dead tissues of the host plant.

Pileus hemispherical, umbilicate, with margin narrowly decurved, sometimes infundibuliform, plicato-sulcate almost to the centre, coriaceous, dark brown in the centre, elsewhere reddish brown, becoming ashy or brownish white, streaked with brown fibrils and points, 1 cm. diameter; stalk up to 1 cm. long, 1 mm. diameter, blackish brown, cartilaginous, rough with minute fascicles of hairs; gills distant, narrow, arched, adnate to a disc at the apex of the stalk, reddish, then creamy white, rather thick, interstices sometimes veined; spores white, narrow oval, inequilateral, sometimes curved at one end, $8-10 \times 3-4 \mu$. In wet low country jungles from 400 to 2000 ft. elevation. Hapugastenne, nos. 2991, 3226, October 1909. This might be known as Elephant Hair Blight.

In *Ann. Perad.* vi, 56, this species was assigned to *M. obscuratus* B. & Br. a re-examination of the type of the latter has shown that it consists of rather young examples of *M. proximus*, and is different from the present species.

Marasmius ascendens Petch, n.sp.

Mycelium rhizomorphic, black, glabrous, angular, flattened and twisted, 0.2-0.4 mm. broad, overrunning the bark of living trees up to a height of 40 or 50 ft. and forming a tangle among the upper branches. Pilei formed on fallen affected branches.

Pileus ashy to purple grey, up to 1 cm. diameter, convex, then plane or repand, sometimes umbonate, membranous, tough, surface minutely rugose; stalk up to 1 cm. long, filiform, 0.2 mm. diameter, or flattened, 0.4 mm. broad, glabrous, horny, black below, purple brown above; gills distant, adnate or very slightly decurrent, very narrow. Hakgala, nos. 4559, 4643, March 1915.

Marasmius actinophorus B. & Br., Fungi of Ceylon, no. 385; *M. coronatus* Petch, *Ann. Perad.* vi, 58.

Mycelium rhizomorphic, about 0.5 mm. diameter, dark brown, closely covered with adpressed white hairs, which are simple, up to 0.6 mm. long,

4–6 μ diameter, septate, thick walled, overrunning shrubs and tree trunks up to a height of about 4 ft. Pilei produced terminally on the mycelium and also on dead branches or the bark of living trees.

Pileus hemispherical, or broadly convex or almost plane, about 1 cm. diameter; centre black or dark brown, depressed, usually with a minute conical umbo, clothed with coarse radially arranged fibrils which project in a fringe beyond the central area, elsewhere, brownish white with radial ridges of coarse hairs which project over the margin; hairs on the pileus, 3.5–4 μ diameter, smooth, simple, thick-walled, flexuose below, separate at the base, cohering above in pointed tapering fascicles up to 0.5 mm. long; stalk 4–7 cm. long, 0.25–0.5 mm. diameter, black, dull, not horny, equal, thickly clothed with adpressed white hairs; gills white, crowded, free, slightly ventricose; spores white, narrow oval, slightly inequilateral, 7–9 \times 4–5 μ . Common at Hakgala (Pl. IV, fig. 16).

***Marasmius Hakgalensis* Petch, n.sp.**

Pileus hemispherical, or broadly campanulate, up to 4 mm. diameter, purple grey or ashy brown, darker in the centre, membranous, minutely rugose, even, not umbilicate or umbonate, feebly striate at the margin; stalk up to 3 cm. long, 0.5 mm. diameter, purple brown or black, equal, horny, clothed with scattered, rigid, spreading, white hairs; gills moderately distant, adnate, white, or pallid with a white edge. On dead leaves and twigs on the ground, associated with black, angular, rhizomorphic mycelium, at first setulose like the stalk, becoming glabrous. Hakgala, common in jungle belts (Pl. IV, fig. 12).

Var. ***denudata*** Petch. Stalk glabrous; gills more crowded, purplish (Pl. IV, fig. 12 left).

***Marasmius Paspali* Petch, n.sp.**

Pileus hemispherical, not umbonate or depressed in the centre, bluish grey, feebly sulcate, pruinose, 2.5 mm. diameter; stalk excentric, blackish, white pruinose, fibrillose, cartilaginous, slightly attenuated upwards, 2 mm. long, 0.2 mm. diameter; gills ochraceous, rather broad, few (three or four, with short intermediates), adnate, interstices veined. On leaf-sheaths of *Paspalum dilatatum*, apparently parasitic. Old Peradeniya, no. 6531, 12 August 1922 (Pl. III, fig. 11).

Marasmius Campanella Holtermann, *Myk. Unters. aus den Tropen* (1898), p. 105; '*Cantharellus capensis*' (in part) in *Fungi of Ceylon*, no. 350. Brown variety, *Marasmius rufescens* B. & Br., *Fungi of Ceylon*, no. 394; *Xerotus tener* B. & Br., *Fungi of Ceylon*, no. 426.

Pileus circular, orbicular, or reniform, up to 4 cm. diameter, but usually about 2 cm., campanulate, then convex, edge often recurved, sulcate over the gills and veins, depressed over the stalk, glabrous, slightly rugose, membranous, tough, not gelatinous, white, grey or purple grey or greyish brown, blackening slightly when old, sometimes rufous, rarely orange; stalk short, excentric, curved, sometimes central, 3–4 mm. long, 1 mm. diameter, solid, at first the same colour as the pileus and clothed with

minute fibrils, then black and glabrous, expanding at the apex, swollen at the base; gills few, usually narrow but sometimes thin and broad (up to 3 mm.), distant, often forked, united by strong veins when old, adnate to the swollen apex of the stalk, the whole lower surface of the pileus slightly paler than the upper; spores white, oblong oval, $7-12 \times 5-6 \mu$. On dead branches, stems of lianes, etc. Generally distributed and frequent (Pl. II, fig. 14; Pl. III, fig. 6; Pl. IV, fig. 18).

This species was discussed in *Ann. Perad.* iv, 404-6 (1910), where it was recorded that Berkeley and Broome's Ceylon specimens of *Cantharellus capensis* contained at least two species, one membranous and stalked, the other gelatinous and usually sessile, which answered to Holtermann's *Marasmius Campanella* and *Favolaschia bispora* respectively, and it was pointed out that Thwaites's figure, no. 90, cited for *Cantharellus capensis* was *Favolaschia bispora*. The latter species was not described until 1912, when it appeared in *Sacc. Syll. Fung.* xxi, 358 as *Laschia bispora* (Holt.) Sacc. & Trav. with a spore measurement the same as *Marasmius Campanella* and certainly wrong for both. These species are said to have been collected in Java, but Holtermann did not give the locality, and as he worked for some time at Peradeniya, and the two formerly occurred in quantity near the entrance to the Botanic Gardens where they could scarcely have been overlooked by a mycologist, it would seem probable that he may have collected them in Ceylon. In *Mycol. Notes*, no. 58 (1919), 815, C. G. Lloyd stated that, from the figure, *M. Campanella* was probably in part *Campanella cucullata* (Jung.) Lloyd, and in no. 70 (1923), 1225, he recorded that Berkeley's Ceylon determinations of *Cantharellus capensis* were *Campanella cucullata*. Both these statements no doubt refer to *Laschia bispora*, but as its spores are not globose it cannot be *Campanella*.

***Marasmius rufo-aurantiacus* Petch, n.sp.**

Pileus at first galeate, then expanded, broadly campanulate or almost plane, orbicular, up to 2 cm. diameter, red brown at first, becoming brownish fawn or buff, smooth, thin, membranous, large specimens sulcate; stalk excentric, white or brownish, minutely powdered or tomentose, tomentose at the base, 2-3 mm. long, 0.3 mm. diameter; lower surface and gills bright orange, fading to fawn; gills adnate, arched, rather broad, edge thick, interstices veined, spotted with clusters of cylindric-clavate cystidia crowned with red brown deposits; spores white, broadly clavate, slightly curved at the apex, $8-12 \times 4 \mu$. On dead twigs and bark. Hakgala, no. 4027, April 1912; no. 4028, March 1914; no. 4130, September 1914 (Pl. II, fig. 13).

***Marasmius porphyreticus* Petch, n.sp.**

Pileus usually galeate, then almost plane, orbicular, stalk excentric, almost lateral, or convex, almost centrally stalked, pale or dark purple brown, rugose, plicato-sulcate, up to 2 cm. diameter; stalk short, 1 mm. diameter, expanding upwards, purple brown, glabrous; lower surface and gills pale purple brown; gills distant, adnate, about six reaching the top of the stalk with shorter intermediate, usually forked, edge thick; spores

white, narrow oval, $7-11 \times 3-4 \mu$. On dead sticks. Hakgala, no. 4126, 28 September 1914 (Pl. II, fig. 11).

Marasmius alliarius Petch, n.sp.

Pileus orbicular, up to 2 cm. broad, membranous, broadly convex, smooth, red brown, sulcate towards the margin when fresh; stalk excentric, very short, expanding upwards, longitudinally silky, white; gills cream-coloured, of three lengths, the longer adnate, arched, distant, broad, interstices veined; spores white, oval, somewhat inequilateral, $7-10 \times 4-5 \mu$. Strong smell of garlic when bruised. On dead wood and sticks. Hakgala, no. 3539, April 1912; no. 3910, January 1914; no. 4060, April 1914; no. 4131, September 1914; no. 5585, December 1917 (Pl. II, fig. 12).

Marasmius ignobilis B. & Br., Fungi of Ceylon, no. 390.

Pileus orbicular, convex, pale fawn-coloured, thin, minutely rugose, up to 8 mm. diameter; stalk white, excentric, curved, up to 1.5 mm. long, 0.5 mm. diameter, pruinose or subtomentose; lower surface white; gills distant, adnate, edge arcuate or straight, sometimes forked, connected by strong veins. Old specimens ochraceous, the stalk blackening at the base. Strong smell of garlic when fresh. On dead twigs on the ground. Henaratgoda, no. 5346, 12 September 1917.

No number or date was cited by Berkeley and Broome for this species, which was said to have occurred on dead wood in the south of the island. In *Ann. Perad.* iv, 391, I referred it to *Oudemansiella subaurantiaca*, basing that opinion on Thwaites no. 100, Peradeniya, which was cited under *Marasmius ignobilis* as a variety. There is, however, in *Herb. Kew.*, in the cover of *M. epochnous*, Thwaites no. 683, a specimen on twigs from the south of the island, marked *M. ignobilis*, which answers to Berkeley and Broome's description and that given above.

Marasmius purpureo-albus Petch, n.sp.

Pileus usually orbicular, up to 3 cm. diameter, stalk excentric, convex, then repand, sometimes centrally stalked, broadly convex, at first pale purple, becoming white or pale ochraceous, depressed or umbilicate over the stalk, irregularly plicate, glabrous; stalk white, stout, up to 1 cm. long, 2 mm. diameter in the middle, equal or expanding upwards, with a ring of tomentum at the base; gills distant, ventricose, the longer sinuato-adnate, white or pallid; spores white, narrow oval, inequilateral, $10-14 \times 5-6 \mu$. On a decaying banana stem, no. 5303, Peradeniya, August 1917. On bark scales on living *Lagerstroemia*, no. 6541, Peradeniya, 21 September 1922; on fallen twigs of *Lagerstroemia*, no. 6557, Peradeniya, 5 November 1922 (Pl. III, figs. 3, 10).

Marasmius Amomi Petch, n.sp.

Pileus at first convex, purple brown, tomentose with spongy tomentum and a few adpressed white hairs, then broadly convex, plane, or irregularly, repand, up to 5 cm. diameter, irregularly radially plicate, purplish brown at the base, elsewhere pale ochraceous, sparsely covered with innate

radiating fascicles of purple brown fibrils, matted silky between; stalk excentric, white, glabrous, expanding upwards, up to 1 cm. long, 1.5 mm. diameter, with a basal tuft or cushion of orange hyphae; gills white or pallid with a purple tinge, distant, adnate, forked, the edge irregularly crisped in repand specimens, interstices veined. On dead stems of *Amomum*. Hakgala, no. 4652, April 1915.

***Marasmius Calami* Petch, n.sp.**

Pileus up to 2 cm. diameter, membranous, broadly convex, strongly sulcate over the gills and irregularly bullate between, white with a greenish tinge, margin when fresh fimbriate with clavate hairs, 3μ diameter below, $4-8\mu$ above; stalk excentric, curved, connate at the base, up to 1 cm. long, 1 mm. diameter, equal, expanded at apex, white, longitudinally silky striate; gills white, rather thick, the longer distant, adnato-decurrent, often forked, with shorter intermediate gills, connected by strong veins; spores white, clavate, $13-16 \times 4-5\mu$. On a dead stem of *Calamus*. Peradeniya, no. 6708; 25 December 1923.

Marasmius pulcher (B. & Br.) Petch, *Ann. Perad.* ix, 21; *Cyphella pulchra* B. & Br., *Fungi of Ceylon*, no. 665.

Mycelium without anker cells, running in stout white cords over the stems and leaves of living shrubs; pilei produced at the edge of the cords or on diffuse patches of mycelium on dead leaves and bark. Pilei sessile, resupinate or laterally attached, sometimes shortly stalked, reniform or orbicular, sometimes lobed, white, becoming pale ochraceous, thin, tomentose, sulcate over the gills, up to 7 mm. diameter; gills radiating from an excentric point, few or absent on small examples, crowded and of medium breadth on the larger; spores white, cymbiform, $6-8 \times 4\mu$. Mycelium (Thread Blight) common in the wet low-country. No. 5269, from Hakgala, may be a different species; it was found running over and among dead bark scales on a dead standing tree trunk and its spores were measured as oval or subglobose, $4-5 \times 3\mu$ (Pl. III, fig. 4).

SPECIES DUBIAE ET EXCLUDENDAE

Marasmius concolor B. & C.

The Ceylon specimens attributed to this species (Thwaites no. 685) are *Crepidotus melleus* (B. & Br.) Petch (*Aschersonia mellea* B. & Br.).

Marasmius epochnous B. & Br., *Fungi of Ceylon*, no. 393; '*M. epochnous* B. & C.' (in error).

This species was said to be white. The pilei in the type are gregarious, up to 3 mm. diameter, orbicular, convex, tomentose; stalk excentric, almost lateral, curved, up to 0.5 mm. long, 0.15 mm. diameter, each arising from a circular patch of radiating hyphae; gills broad, adnate, distant. The pileus and gills are very friable, and it does not seem a good *Marasmius*. It was collected in the south of the island and has not been matched by recent

specimens. It probably grew on the under surface of a branch as, in the herbarium specimen, the stalks curve towards the substratum, so that the lower surface of the pileus is uppermost.

Marasmius (Mycena) galericula Ces.

This species was collected by Beccari in the Botanic Gardens, Peradeniya, and was described by Cesati as 'subfuniculate, lignicolous; stalk three inches long, filiform, horny, rigid, brown, flexuose (not twisted), smooth, scarcely pulverulent or pruinose, but opaque; pileus campanulate, one inch diameter, colour when dry lurid, with the appearance of an agaric of the series *Mycenae rigidipes*, collapsed when old. From the development of the stalk I am doubtful as regards *Marasmius*.' *Mycenae rigidipes* is Fries's section of *Mycena* which includes *Mycena galericulata*, and from Cesati's choice of a name it might be surmised that he saw some resemblance to that species. I am unable to suggest what it may have been.

Marasmius inustus B. & Br., Fungi of Ceylon, no. 384.

The type resembles rather small specimens of *M. Campanella*, somewhat thicker than usual, and stained black here and there, as though it changed colour when bruised. They have not been matched by fresh specimens and may be a distinct species. They are not gelatinous.

Marasmius prasinus B. & Br., Fungi of Ceylon, no. 373.

Berkeley and Broome described this as pileus 3 cm. across, of a delicate greyish green, somewhat fleshy, glabrous, margin irregular, sulcate, flesh white; stalk 3 cm. long, 1.5 mm. thick; gills narrow, arcuate, decurrent, ochraceous; on dead twigs, etc. No Thwaites number, locality or date was cited, and there was no painting. The type in Herb. Kew. consists of a single pileus pressed flat, about 4 cm. diameter, extremely thin. It bears on the lower surface radial bands of loose tissue, bounded by denser lines, and examination shows that the gills have been cut away, leaving the trama bounded by their bases. Pieces of the gill remain towards the margin, but these do not show anything which would afford a clue to its identity. It would seem that the specimen has been cut up for preservation, but if so the other pieces are not in Herb. Kew. It is not possible to determine anything from the specimen, and I never found anything to fit the description.

Marasmius proletarius B. & C.

This species from Cuba was described as white. The Ceylon painting, Thwaites No. 1170, shows a coloured pileus and represents young specimens of *M. coniatu*s. The name should be deleted from the Ceylon list.

Marasmius radians B. & Br., Fungi of Ceylon, no. 366.

Thwaites no. 103 was divided by Berkeley and Broome into two species, *Cantharellus inaequalis* B. & Br., Fungi of Ceylon, no. 347, and *Marasmius radians* B. & Br. There was no painting. The two appear to be the same, and a *Cantharellus*, but until fresh specimens have been collected, the question may remain open. Both grew on wood or sticks.

Marasmius sulciiceps Berk., Decades of Fungi, no. 156.

Pileus broadly convex, depressed, ochraceous, thin (? through drying), about 2 cm. diameter, minutely scurfy, no special pellicle; stalk compressed, cartilaginous, minutely pruinose, white, strigose at the base, with tawny mycelium spreading over the substratum, about 2 cm. long, stout when fresh, 1 mm. broad in the dry specimen; gills ventricose, adnate, moderately crowded; spores yellow brown, oval or obliquely oval, apiculate, $6 \times 4 \mu$. On rotten wood.

This species has not been identified again. It was sent by Gardner, with a figure which shows a stout white stalk and a depressed ochraceous pileus. The radial grooves noted by Berkeley are probably the result of drying. It appears to be a *Naucoria*.

Marasmius Wynniae var. *auricolor* B. & Br., Fungi of Ceylon, no. 353.

This is a *Mycena*, which may be known as *Mycena auricolor* Petch, nom. nov.

Solitary or caespitose; pileus up to 2.5 cm. diameter, broadly convex, then almost plane, slightly depressed in the centre, margin striate when moist, pale lilac, rose in the centre, becoming entirely rose pink, or when young everywhere rose pink with a purplish tinge, pallid when old, sprinkled with minute glistening particles when dry; flesh thin, white in the centre; gills paler than the pileus, adnate or adnato-decurrent, narrow, 3 mm. broad, attenuated outwards, lower edge straight, interstices strongly veined; stalk up to 5 cm. long, 2.5 mm. diameter, equal, coloured like the pileus, hollow, smooth, shining, brittle, sometimes ridged above with decurrent lines from the gills, slightly strigose at the base; spores white, oval, $6-8 \times 4 \mu$. On the ground among vegetable refuse. Peradeniya, 1 July 1908; 1 August 1909; also no. 4142.

The specimen Thwaites no. 204 cited by Berkeley and Broome as 'the same thing' is *M. leucophaeus*.

LATIN DESCRIPTIONS OF NEW SPECIES

Marasmius purpureo-griseus Petch, sp. nov. Fasciculatus; pileo late convexo, margine pallidiori, minute radiatim sericeo, ca. 1.5 cm. diam., margine incurvato; carneo albo tenui; stipite ad 4 cm. alt., 1.5 mm. diam., brunneo-albo, nitenti, cartilagineo, farcto dein cavo, fistuloso; lamellis confertis, albis vel cremeis, latis, adnatis v. sinuato-adnatis, acie recta. Ad lignum emortuum, mycelio albo affixus. Henaratgoda, Ceylon.

Marasmius rufo-ochraceus Petch, sp. nov. Fasciculatus v. sparsus; pileo late convexo v. fere plano et undulato, ad 3.5 cm. diam., centro rufo-brunneo, ad marginem ochraceo v. pallido, sicco toto ochraceo, radiatim sulcato, glabro, tenui, cartilagineo; stipite ad 3 cm. alt., compresso, ad 3 mm. lat., cartilagineo, rufo-brunneo, supra pallidiori, glabro v. minute tomentoso, farcto dein cavo; lamellis subremotis, subventricosis, adnatis, pallidis, brunnescentibus, aetate interstitiis valde venosis; sporis albis, clavatis, $10-14 \times 5-6 \mu$. Ad lignum emortuum. Hakgala, Ceylon.

Marasmius brunneostriatus Petch, sp. nov. Pileo campanulato dein fere plano, obtuse umbonato, ad 2 cm. diam., rufo, centro saturatiori, margine

pallidiori flavo-brunneo, radiatim sulcato, sulcis saturatoribus, minute rugoso, margine saepe repando; stipite ad 2 cm. alt., 1 mm. diam., apice incrassato, cartilagineo, rufo-brunneo, pruinoso v. minute tomentoso, basi tomentoso, e strato tenui albo oriundo; lamellis pallido-ochraceis, distantibus, crassiusculis, angustis, aequalibus, adnatis; sporis albis, clavatis v. ovalibus, $5-9 \times 3-4 \mu$. Ad folia et ramulos dejectos. Hakgala, Ceylon.

Marasmius senescens Petch, sp. nov. Pileo 1.5 cm. diam., late convexo, centro depresso, interdum umbonato, plicato-sulcato, centro corrugato, sordide griseo margine pallidiori, tenui, centro leniter tomentoso, alibi sparsim fibrilloso et hinc illic consperso; stipite 1 cm. alt., 1.5 mm. diam., supra expanso, albo v. cinereo, fusciscenti, compresso, striato, minute longitudinaliter sericeo, cartilagineo; lamellis distantibus, adnatis v. adnato-decurrentibus, circum apicem stipitis connexis et separantibus, latis, leniter ventricosus, crassiusculis, furcatis, pallidis, brunnescentibus, interstitiis venosis; sporis albis, angusto-ovalibus, subpyriformibus, $7-10 \times 3-4 \mu$. Ad terram. Peradeniya, Ceylon.

Marasmius styphinoides Petch, sp. nov. Pileo albo, centro cinereo, late convexo v. fere plano, ad 5 mm. diam., umbilicato, leniter radiatim sulcato, minute rugoso, margine crenato; stipite ad 8 mm. alt., 0.4 mm. diam., saepius curvato, primo albo dein nigrescenti, pulverulento, striato, apice incrassato; lamellis albis, confertis, subventricosus, acie serrato. Ad corticem emortuum. Hakgala, Ceylon.

Marasmius cineraceus Petch, sp. nov. Pileo infundibuliformi, margine decurvo, leniter radiatim sulcato, 9 mm. diam., cinereo, levi, pellicula hypharum intertextarum; stipite nigro, albo-pruinoso, cartilagineo, 1 cm. alt., 0.75 mm. diam., aequali, e disco glabro rotundato oriundo; lamellis subconfertis, albis, sigmoideis, latis, adnato-decurrentibus, acie serrato, interstitiis venosis. Ad folia emortua. Peradeniya, Ceylon.

Marasmius subconiciatus Petch, sp. nov. Pileo ad 5 mm. diam., late convexo, plicato-sulcato, umbilicato, obscure rufo-brunneo, particulis hyalinis consperso, cellulis pelliculae spinis conicis confertis coronatis; stipite ad 6 mm. alt., crasso, 0.4 mm. diam., nigro-brunneo, glabro, cartilagineo; lamellis numerosis (14), distantibus, cremeis, latis, acie recta v. subventricosus, late adnatis. Ad bambusam emortuam. Peradeniya, Ceylon.

Marasmius lateritius Petch, sp. nov. Pileo convexo v. conico-convexo, plano v. obtuse umbonato, ad 6 mm. diam., pallide rubra v. lateritio, saepe maculis flavis; stipite ad 2.5 cm. alt., 1 mm. diam., primo albo dein flavo-brunneo, corneo, minute hispido, basi strigoso; lamellis albis dein flavis, non distantibus, postice rotundatis v. truncatis, liberis sed stipitem approximatis; sporis albis, clavatis, $10-13 \times 3-4 \mu$. Ad terram inter folia emortua. Peradeniya, Ceylon.

Marasmius albocapitatus Petch, sp. nov. Pileo candido, hemisphaerico, ad 4 mm. diam., minute umbilicato, leniter sulcato; stipite 1.5 cm. alt., 0.2 mm. diam., nigrobrunneo, setaceo; lamellis albis, angustis, adscendentibus, adnatis, acie obtuso; sporis albis, anguste ovalibus, $8-10 \times 3 \mu$; pileo et stipite crines longos patentes flavo-brunneos, attenuatos, acutos, infra 4 μ diam., ad 0.35 mm. alt. ferentibus; stipite etiam crinibus minutis, irregularibus, saepius curvatis, ad $30 \times 6 \mu$, vestitis; cystidiis acie lamellarum

ampullaceis, ad 34μ alt., infra 12μ diam. Ad folia emortua. Hakgala, Ceylon.

Marasmius micraster Petch, sp.nov. Pileo 3 mm. diam., udo fere plano, sicco campanulato et radiatim plicato, nigrobrunneo v. flavobrunneo, in sulcis saturatori, membranaceo, centro depresso et corrugato, cellulis pelliculae ca. 16μ diam., externe valde verrucosis; stipite setaceo, nigrobrunneo, glabro, nitenti, ca. 1 cm. alt., 0.2 mm. diam.; lamellis paucis, albis v. cremeis, ventricosis, liberis; cystidiis ampullaceis, ad 16μ alt., apice truncatis; sporis albis, ovalibus, uno fine acutis, $10-12 \times 4-5\mu$. Ad ramulos emortuos. Peradeniya, Ceylon.

Marasmius tubulatus Petch, sp.nov. Pileo cylindrico-campanulato, profunde umbilicato, plicato-sulcato, pruinoso, membranaceo, ad 8 mm. diam., pallido dein brunneo-cinereo, margine pallidiori, centro nigro; stipite ad 2 cm. alt., 0.3 mm. diam., nigro-brunneo, corneo, glabro, nitenti, longitudinaliter striato; lamellis distantibus, albis dein pallidis, acie brunneo-griseo, subtriangularibus, postice in tubulo junctis; sporis albis, ovalibus v. clavatis, $7-9 \times 3-4\mu$. Ad folia et ramulos emortuos. Peradeniya, Ceylon.

Marasmius griseo-violaceus Petch, sp.nov. Pileo campanulato, ad 1 cm. diam., umbilicato, plicato-sulcato, membranaceo, griseo-violaceo v. purpureo-brunneo v. centro fere nigro alibi nigro-griseo, udo minute nigro-rugoso; stipite ad 7 cm. alt., 0.5 mm. diam., supra attenuato, rigido, corneo, nigro, nitenti; lamellis albis, distantibus, arcuatis v. triangularibus, acie colorati, in collarium liberum postice conjunctis; sporis albis, ovalibus, inaequilateralibus, $8-11 \times 6\mu$. Mycelio nigro rhizomorphaideo, 0.25 mm. diam. Basi *Dendrocalami gigantei* et ad folia emortua. Peradeniya, Ceylon.

Marasmius rigidichorda Petch, sp.nov. Pileo hemisphaerico, umbilicato, margine anguste decurvo, interdum infundibuliformi, plicato-sulcato, coriaceo, centro fusco-brunneo, alibi rubro-brunneo, fibris et punctis brunneis radiato, 1 cm. diam.; stipite ad 1 cm. alt., 1 mm. diam., nigro-brunneo, cartilagineo, scabro; lamellis distantibus, angustis, arcuatis, adnatis, rubescentibus dein cremeis, crassiusculis; sporis albis, angustovalibus, inaequilateralibus, $8-10 \times 3-4\mu$. Mycelio aereo rhizomorphaideo, nigro, rigido, 0.4-0.6 mm. diam. Ad frutices. Hapugastenne, Ceylon.

Marasmius ascendens Petch, sp.nov. Pileo cinereo v. purpureo-griseo, ad 1 cm. diam., convexo dein plano v. repando, interdum umbonato, membranaceo, tenaci, minute rugoso; stipite ad 1 cm. alt., 0.2 mm. diam., setaceo, v. compresso, 0.4 mm. lat., glabro, corneo, infra nigro, supra purpureo-brunneo; lamellis distantibus, adnatis v. leniter decurrentibus, angustissimis. Mycelio aereo rhizomorphaideo, nigro, glabro, angulato, compresso et torto. Ad truncos et ramos arborum vivorum. Hakgala, Ceylon.

Marasmius Hakgalensis Petch, sp.nov. Pileo hemisphaerico v. late campanulato, ad 4 mm. diam.; purpureo-griseo v. cinereo-brunneo, centro saturatori, membranaceo, minute rugoso, margine leniter striato; stipite ad 3 cm. alt., 0.5 mm. diam., purpureo-brunneo v. nigro, aequali, corneo, setuloso; lamellis subdistantibus, adnatis, albis, v. pallidis acie albo. Mycelio rhizomorphaideo, terrestri, nigro, angulato, setuloso dein glabro. Ad folia et ramulos emortuos. Hakgala, Ceylon.

Var. *denudata* Petch. Stipite glabro; lamellis magis confertis, purpurascensibus.

Marasmius Paspali Petch, sp.nov. Pileo hemisphaerico, coerulesco-griseo, leniter sulcato, pruinoso, 2.5 mm. diam.; stipite excentrico, nigrescenti, fibrilloso, cartilagineo, 2 mm. alt., 0.2 mm. diam.; lamellis ochraceis, latiusculis, paucis, adnatis, interstitiis venosis. Ad vaginas *Paspali dilatati*. Peradeniya, Ceylon.

Marasmius rufo-aurantiacus Petch, sp.nov. Pileo primo galeato, dein expanso, late campanulato v. fere plano, orbiculari, ad 2 cm. diam., primo rubro-brunneo, dein brunneo-cervino, levi, tenui, membranaceo, majoribus sulcatis; stipite excentrico, albo v. brunnescenti, minute pulverulento v. tomentoso, basi tomentoso, 2-3 mm. alt., 0.3 mm. diam.; lamellis vivide aurantiacis dein cervinis, adnatis, arcuatis, latiusculis, acie crasso, interstitiis venosis, acervulis cystidiorum cylindrico-clavatorum massis rufis coronatorum maculatis; sporis albis, late clavatis, apice leniter curvatis, $8-12 \times 4 \mu$. Ad corticem et ramulos emortuos. Hakgala, Ceylon.

Marasmius porphyreticus Petch, sp.nov. Pileo saepius galeato, dein fere plano, orbiculari, stipite excentrico, v. convexo, stipite fere centrali, purpureo-brunneo, rugoso, plicato-sulcato, ad 2 cm. diam.; stipite brevi, 1 mm. diam., supra incrassato, purpureo-brunneo, glabro; lamellis paucis, purpureo-brunneis, distantibus, adnatis, saepius furcatis, crassis; sporis albis angusto-ovalibus, $7-11 \times 3-4 \mu$. Ad ramulos emortuos. Hakgala, Ceylon.

Marasmius alliarius Petch, sp.nov. Pileo orbiculari, ad 2 cm. lat., late convexo, membranaceo, levi, rufo-brunneo, margine sulcato; stipite excentrico, brevissimo, supra incrassato, longitudinaliter sericeo, albo; lamellis cremeis, majoribus adnatis, arcuatis, latis, interstitiis venosis; sporis albis, ovalibus, $7-10 \times 5 \mu$. Contuso alliatus. Ad lignum et ramulos emortuos. Hakgala, Ceylon.

Marasmius purpureo-albus Petch, sp.nov. Pileo saepius orbiculari, ad 3 cm. diam., convexo, repando, stipite excentrico, interdum stipite centrali, late convexo, primo pallide purpureo, dein albo v. pallide ochraceo, postice depresso v. umbilicato, vage plicato, glabro; stipite albo, crasso, ad 1 cm. alt., medio 2 mm. diam., aequali v. supra incrassato, basi annulari-tomentoso; lamellis distantibus, ventricosus, majoribus sinuato-adnatis, albis v. pallidis; sporis albis, angusto-ovalibus, inaequaliter albis, $10-14 \times 5-6 \mu$. Ad caulem marcidum *Musae* (Banana), et ad corticem vivae *Lagerstroemiae*. Peradeniya, Ceylon.

Marasmius Amomi Petch, sp.nov. Pileo primo convexo, purpureo-brunneo, spongioso-tomentoso, dein late convexo v. plano v. vage repando, ad 5 cm. diam., vage radiatim plicato, postice purpureo-brunneo, alibi pallide ochraceo, innatis radiantibus fasciculis purpureo-brunnearum hypharum sparsim induto; stipite excentrico, albo, glabro, supra incrassato, ad 1 cm. alt., 1.5 mm. diam., basi aurantiaco-tomentoso; lamellis albis v. purpurascensibus, distantibus, adnatis, furcatis, interstitiis venosis. Ad caules emortuos *Amomi*. Hakgala, Ceylon.

Marasmius Calami Petch, sp.nov. Pileo ad 2 cm. diam., late convexo, membranaceo, super lamellis valde sulcato, inter vage bullato, viridi-albo,

margine udo fimbriato crinibus clavatis infra 3μ diam., supra $4-8\mu$; stipite excentrico, curvato, connexo, ad 1 cm. alt., 1 mm. diam., aequali, apice incrassato, sericeo-striato; lamellis albis, crassiusculis, distantibus, adnato-decurrentibus, saepe furcatis, venis validis connexis; sporis albis, clavatis, $13-16 \times 4-5\mu$. Ad caulem emortuum Calami. Peradeniya, Ceylon.

EXPLANATION OF PLATES

(All figures natural size, unless otherwise stated; numbers in brackets are those of the specimens from which the figures were drawn.)

PLATE II

- Fig. 1. *M. nephelodes*, and section.
- Fig. 2. *M. rivulosus*, full-grown, young, and section (4380).
- Fig. 3. *M. Caryotae*, and section.
- Fig. 4. *M. hirtellus*, and surface view of pileus (4294).
- Fig. 5. *M. pallido-rubens*, and section (4382).
- Fig. 6. *M. crispatus*, and under-surface (4239).
- Fig. 7. *M. brunneostriatus*, and section (4116).
- Fig. 8. *M. calvus*, and section (4115).
- Fig. 9. *M. proximus* (4152).
- Fig. 10. *M. corticigena*, full grown, section, and young (4370).
- Fig. 11. *M. porphyreticus*, upper and under-surface (4126).
- Fig. 12. *M. alliaris*, upper and under-surface (4131).
- Fig. 13. *M. rufo-aurantiacus*, under and upper surface (4130).
- Fig. 14. *M. Campanella*, small specimen (4124).

PLATE III

- Fig. 1. *M. congregatus*, and section.
- Fig. 2. *M. leucophaeus*, large example (4215).
- Fig. 3. *M. purpureo-albus*, upper and under-surface, from banana (5303).
- Fig. 4. *M. pulcher*, $\times 2$ (5269).
- Fig. 5. *M. subcinereus*, arboreal form, under-surface, $\times 2$ (6542).
- Fig. 6. *M. Campanella*, ochraceous form (4748).
- Fig. 7. *M. purpureo-griseus* (5736).
- Fig. 8. *M. equicrinis*, and under-surface.
- Fig. 9. *M. tubulatus* (4243).
- Fig. 10. *M. purpureo-albus*, central (6557) and lateral (6541) stalked, from *Lagerstroemia*.
- Fig. 11. *M. Paspali*, $\times 2$ (6531).
- Fig. 12. *M. nivosus* (6552).
- Fig. 13. *M. hirtellus* var., and upper surface, $\times 2$ (5807).
- Fig. 14. *M. subcinereus* (6627).
- Fig. 15. *M. multijugus*, and section (6256).

PLATE IV

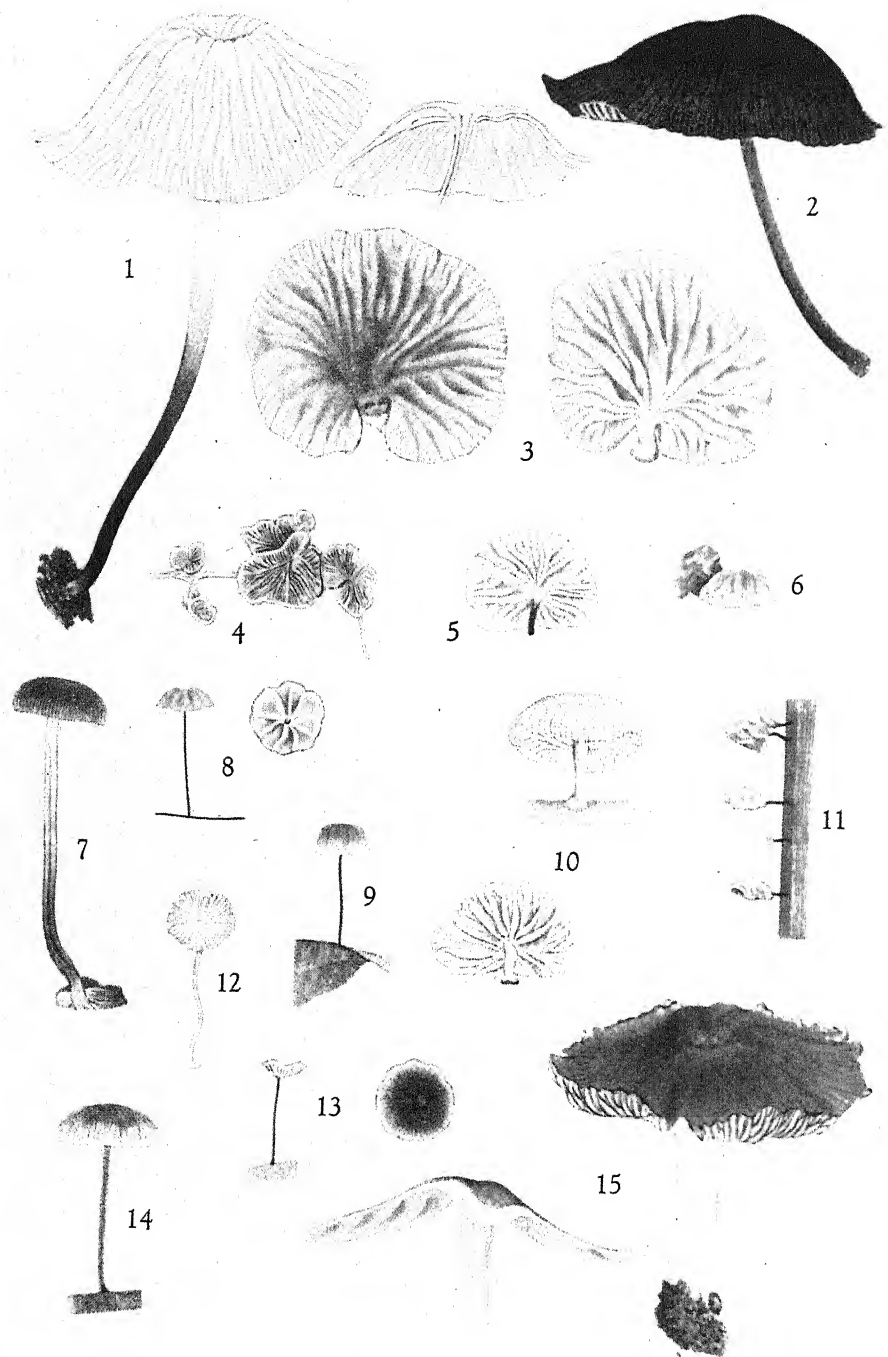
- Fig. 1. *M. coniatius* (4221).
- Fig. 2. *M. Leveillianus*, and section (4625).
- Fig. 3. *M. florideus*, large example (4207), and section of small example (4281).
- Fig. 4. *M. haematocephalus* (4102).
- Fig. 5. *M. lateritius*, and section (4375).
- Fig. 6. *M. fulviceps* (4077).
- Fig. 7. *M. gordipes*, and under-surface (4235).
- Fig. 8. *M. semipellucidus*, and section (4305).
- Fig. 9. *M. Thwaitesii*, and under-surface (4353).
- Fig. 10. *M. hypochroides*, large example (4244).
- Fig. 11. *M. hypochroides*, small example and section.
- Fig. 12. *M. Hakgalensis* (right) (4133), and var. *denudata* (left) (4125).
- Fig. 13. *M. helvolus* var. *brunneolus* (4204).
- Fig. 14. *M. griseoviolaceus*, and under-surface (4238).
- Fig. 15. *M. albocapitatus*, and under-surface (4127).
- Fig. 16. *M. actinophorus* (4134).
- Fig. 17. *M. stypinus*, young (left), full grown (middle) and section (right) of young example (4248).
- Fig. 18. *M. Campanella*, under-surface (4122).

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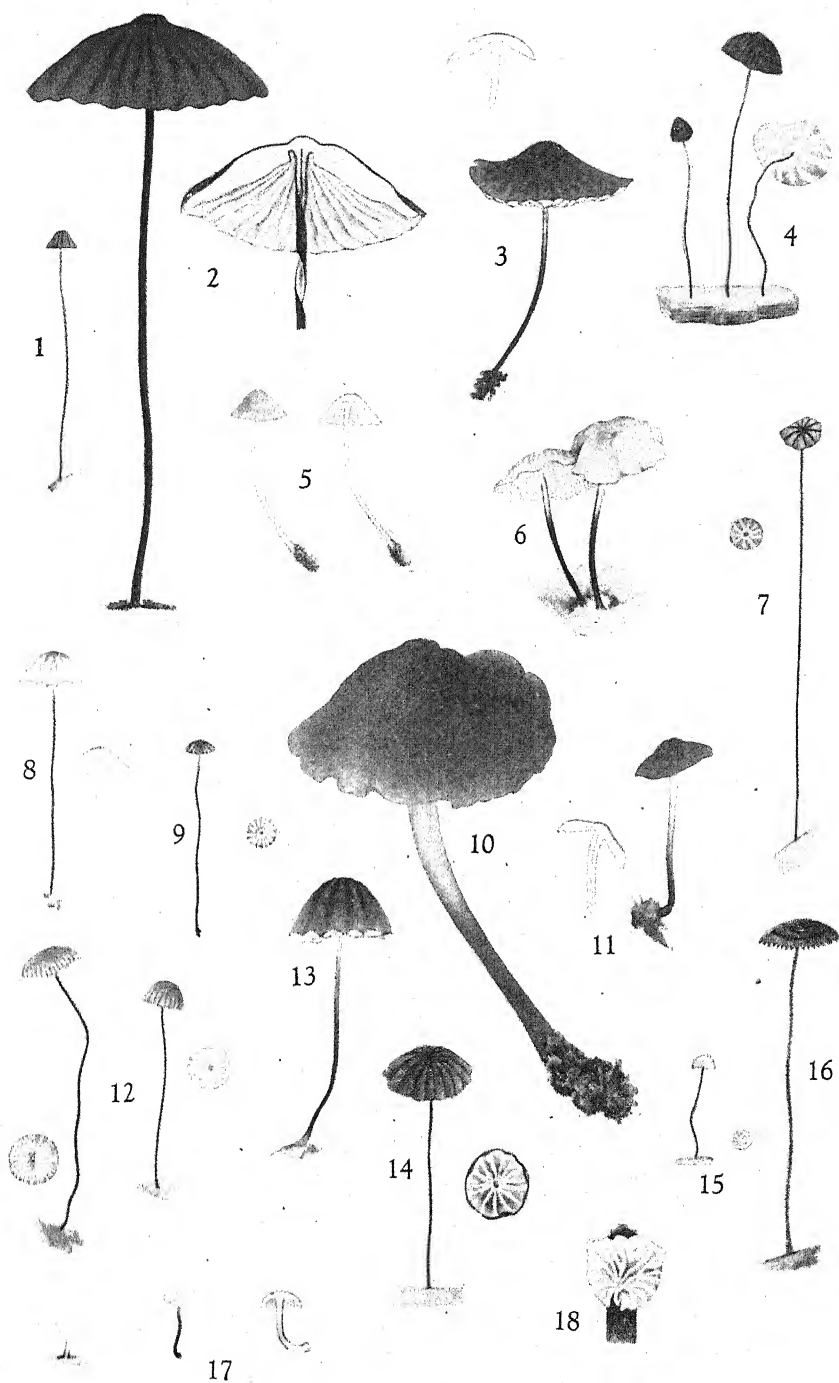
Ceylon *Marasmii*

A. George Alwis del.



Ceylon Marasmii

A. George Atwis del.



Ceylon *Marasmii*

A. George Alwis del.

THE DEPENDENCE ON THE WEATHER OF THE DATES OF OUTBREAK OF POTATO BLIGHT EPIDEMICS

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THE DUTCH RULES FOR FORECASTING BLIGHT EPIDEMICS

Many observations have been made on the relation between weather conditions and the dates of outbreak of potato blight epidemics. Very little of practical value was discovered until van Everdingen (1926), from an examination of Dutch weather data, established four conditions which must be satisfied before outbreaks of blight occur. The value of this work was that, for the first time, it enabled forecasts to be made of the probable occurrence of blight and, therefore, of the date when spraying to control the disease should be begun.

Van Everdingen's conditions (which will be referred to here as the Dutch rules) were as follows:

- (1) Dew occurring for at least four hours during the night.
- (2) Minimum night temperature not less than 10° C. (50° F.).
- (3) Mean cloudiness of the day following the dew not less than 0.8.
- (4) Rainfall on the day following the dew of at least 0.1 mm.

If any day occurred on which all these conditions were obeyed, blight usually made its appearance within a fortnight.

These rules have been applied successfully in Holland and a spray warning service organized there (van Poeteren, 1928, 1931; van Everdingen 1935). They have also been tested in other countries. Wiltshire (1931) applied them to data from a number of places in England and Wales for the years 1921-7. Although the rules were often obeyed, the results on the whole were less satisfactory than in Holland. Better results were obtained when slight deviations were permitted in the application of the rules (e.g. three hours' dew formation instead of four, or 49° F. instead of 50° F.), and such a procedure seemed reasonable because the conditions governing biological phenomena can rarely be expressed with rigid arithmetical precision. This has the practical drawback, however, that it becomes much more difficult to apply a spray warning service with confidence because there is a large increase in the number of almost favourable days which are not followed by blight within a fortnight. I have applied the Dutch rules to the weather data at Newton Abbot, Devon (Beaumont, 1929-32) and, as will be seen, have come to the same conclusion as Wiltshire. The Dutch rules were satisfactorily applied by Dufrenoy (1933) at Bordeaux in 1932 and by Naoumova (1935) in the neighbourhood of Leningrad in 1933 and 1934.

It may be useful at this stage to discuss the phytopathological significance of the rules. Thanks to the work of Melhus (1915), Crosier (1934) and others, we have a great deal of information about the biology of the blight

fungus which is directly relevant to the rules. Blight appears in the crop as a result of planting one or more infected tubers, in the aerial shoots from which the blight fungus develops as soon as conditions are favourable. There are two stages preceding the first visible appearance of blight in what may be called primary infection foci, namely, growth of mycelium in the shoot and formation of conidia. The first stage is governed only by temperature, which is covered by the second of van Everdingen's rules, and which will have a cumulative effect during the growth of the plant. Crosier (1934) has shown that the fungus grows most rapidly at 18–21° C. (64–69° F.) and very slowly below 9° C. (48° F.) or above 24° C. (75° F.). The formation of conidia is governed both by temperature and humidity: the optimum temperature is 18–22° C. (64–72° F.).

The other three rules of van Everdingen relate to the dissemination of blight rather than to the formation of primary infection foci. Naturally, if conditions were quite unfavourable to the spread of blight, the disease would not be reported, as it is unlikely that during ordinary field observation the primary infections would be noticed. It is well known that infection by *Phytophthora infestans* takes place most readily when zoospores are formed, and this occurs only when there is a film of moisture on the leaf. The longer the film of moisture persists the greater is the chance of infection. Dew formation (rule 1) followed by cloudy skies (rule 3) and a certain amount of rain (rule 4) mean that the moisture will last a considerable time and the rules therefore allow for the conditions under which blight will spread sufficiently to form a noticeable outbreak.

APPLICATION OF THE DUTCH RULES TO SOUTH DEVON

Difficulties arise when using the Dutch rules owing to the nature of the meteorological data to be consulted. Dew formation cannot be directly observed, but the period may be estimated by comparing the continuous temperature record with the dew points recorded at 21 hr. (the night before) and at 9 hr. in the morning. It is by no means certain how closely the period obtained in this way corresponds with the actual period of dew formation on potato leaves. Dew does not readily form on potato leaves; much less readily, for example, than on grass. At most stations continuous temperature records are not available and in Table 1 dew formation has been regarded as occurring if the minimum temperature (read at 9 a.m.) was more than 2° F. below the dew point (also read at 9 a.m.).

The meteorological data for the amount of cloud usually refer to one observation only (9 a.m.) and in no case to more than three, and in 1931 they ceased to be recorded at most English stations. The sunshine record would seem to give a better idea of the general cloudiness during the day and in Table 1 a maximum of five hours' sunshine has been allowed.

The rainfall condition is most variable in its application. A combination of a little rain and little sunshine generally means persistent moisture on the leaves. But rain in the morning is often succeeded by wind and intermittent sunshine during the afternoon, and potato leaves dry up very readily under these conditions. It cannot be expected that the variety of

weather conditions can adequately be summed up in a simple rule, and these limitations must be accepted.

Another difficulty is that the nearest meteorological station for which recorded data are available may be some distance from the potato field. This was unavoidably so in Wiltshire's observations, but in the Newton Abbot results given below the meteorological instruments were either in or very close to the potato field.

In arriving at Table 1 the Dutch rules have therefore been modified as follows:

- (1) Minimum temperature not less than 2° F. below the dew point.
- (2) Minimum temperature not less than 50° F.
- (3) Sunshine of the following day not more than five hours.
- (4) Rainfall of the following day at least 0·1 mm.

Table 1. *South Devon*

1 Year	2	3	4	5	6	7	8
1929	11 July	4	1	39	1	1	8
1930	2 Aug.	3	2	43	3	0	52
1931	10 June	3	2	3	3	3	4
1932	15 July	4	1	42	2	0	41
1933	29 July	7	2	58	2	1	57
1934	16 Aug.	9	5	57	0	0	—
1935	26 Aug.	10	3	81	3	1	66
1936	25 July	8	2	34	3	1	22
1937	20 July	8	5	28	0	0	—
1938	8 Aug.	8	1	51	1	1	9
1939	24 July	7	3	32	1	0	18
		71	27	468	19	8	277
				Mean 42·5			Mean 31

Table 1 a. (*The same excluding 1931 and excluding May and June*)

1 Year	2	3	4	5	6	7	8
1929	—	1	1	9	1	1	8
1930	—	2	2	6	1	0	18
1932	—	1	1	2	0	0	—
1933	—	4	2	21	1	1	11
1934	—	7	4	35	0	0	—
1935	—	4	3	55	1	1	1
1936	—	6	3	24	3	1	22
1937	—	6	5	17	0	0	—
1938	—	4	1	32	1	1	9
1939	—	5	3	20	1	0	18
		40	25	221	9	5	87
				Mean 22			Mean 12

Column 2. Date of outbreak of blight.

3. No. of critical periods preceding outbreak (Dutch rules).

4. No. of critical periods in the fifteen days preceding outbreak (Dutch rules).

5. No. of days between first critical period and outbreak, excluding May (Dutch rules).

6, 7 and 8. As 3, 4 and 5 respectively but determined according to the temperature-humidity rule.

The data obtained from the weather records (not published here owing to lack of space) are summarized in Table 1. Examination of columns 3,

4 and 5, obtained by the application of the Dutch rules to the weather data, shows that the outbreak of blight was preceded within fifteen days by one or more critical days in every year from 1929 to 1939. If there had been only one such day before the blight outbreak an accurate forecast of the latter could have been made. With two or three critical days within the fifteen-day period, it would still be possible to give a useful and closely approximate forecast. But in every season critical days occurred which were more than fifteen days before the outbreak and in every year except 1931 the first critical day recorded was, in fact, a much longer period ahead of the blight outbreak. There were indeed forty-four such days out of a total of seventy-one, or 62 %. Even if we consider a twenty-one-day interval as of practical value (i.e. forecasts of blight would take the form of possible outbreaks any time up to three weeks from the date of forecast) the percentage of premature forecasts would still be as much as 56 %.

A possible explanation of the number of premature forecasts is that the chances of blight appearing in epidemic form vary in the different months according to the growth of the crop. Obviously the chances of blight appearing before the shoots are through the ground are nil, whatever the weather, but as growth proceeds and leaves and shoots become more numerous the chances of blight will become greater. In other words, a favourable period in July is more likely to be followed by blight than one in June, while in May the chances are still less. Critical days are rare in May because the temperature is generally too low (only one day in each of seven seasons out of the eleven). In the seasons under investigation blight appeared in June only once (1931). In Table 1*a* critical days earlier than July are disregarded. We now find that all the critical days are followed by blight within fifteen days in three seasons out of ten, and within twenty-one days in six seasons. The percentages of premature forecasts are reduced to 37 and 15 % respectively. This is a big improvement. Apart from 1931, therefore, good results were obtained when considering only the July and August data. It is, however, important to be able to forecast when blight may come exceptionally early, as it did in 1931, because spraying earlier than usual would have been essential in that year. The application of the Dutch rules does not indicate why 1931 was so exceptional.

THE TEMPERATURE-HUMIDITY RULE

The Dutch rules do not take into account the relative humidity of the atmosphere, perhaps because adequate data were not available. The importance of high humidity in relation to the formation of conidia is well known and should be considered (Beaumont, 1930). This was done, and it was found that humidity and temperature alone were sufficient to give a practically useful indication of the likelihood of blight. When the data are available the application of a 'temperature-humidity rule' is much simpler than the use of the Dutch rules.

When this rule was first adopted relative humidity records were being made at 9, 15 and 21 hr. and these enabled a fairly reliable picture to be obtained of the degree of humidity throughout the day. Unfortunately

only the 9 hr. reading was made from 1936 onwards, and as relative humidity usually diminishes during the afternoon such restricted data are of no value for our present purpose. This restricts the application of new rules to the few stations that possess continuous recording instruments or take sufficient hygrometric readings during the day. It is true that the absolute humidity of the air varies little during the day, and the relative humidity, which depends on temperature, can be calculated if the latter is known. Nevertheless, it would be a great help if direct readings of relative humidity at 15 hr. could be re-started. The Meteorological Office (1928) recognized that 'important variations in relative humidity occur during the hours of daylight between 7 and 21 hr. and are not adequately disclosed by observations at 7, 8, 9, 18 or 21 hr. An observation in the early afternoon is required to indicate the extent of the fluctuations'. The 13 hr. reading given in the Daily Weather Map goes some way to supply this need.

During a period of high humidity there is an absence of wind, and the drop in temperature that always occurs at night is often sufficient to induce dew formation, while the film produced does not dry up readily owing to the dampness of the air. This is especially likely when the high humidity persists for forty-eight hours. In effect, therefore, the humidity conditions comprise in one rule the Dutch rules 1, 3 and 4.

The new conditions proposed may be stated as

(1) Minimum temperature not less than 50° F.

(2) Relative humidity not below 75 % for at least two days.

Table 1 gives the number of critical periods preceding the outbreak of blight in each year, a critical period being defined as one in which the required temperature and humidity were both observed for two or more consecutive days. For comparison with the Dutch rules the total number of periods and the number of periods up to fifteen days before the outbreak are both given, as well as the number of days after the first critical period when blight was noted. In 1929 and 1930 only three humidity readings, at 9 a.m., 3 p.m. and 9 p.m., were available, but in subsequent seasons the data were taken from a recording hygrometer kept in a screen placed among the potatoes.

Columns 6, 7 and 8 show that blight was preceded by one or more critical periods, not in every season, as with the Dutch rules, but in nine seasons out of eleven. On the basis of the temperature-humidity rule, therefore, no spray forecast would have been issued in 1934 and 1937. Actually the epidemics were very slight in those years, so that the practical disadvantages of the failure to forecast are not great, a point that will be discussed further below. The temperature-humidity rule has the advantage over the Dutch rules in that in any given season the number of critical periods is smaller, so that a forecast can be made with more certainty (compare column 6 with column 3). The table shows that in 1929 and 1938 there was only one critical period, and in 1931 all the three critical periods were within the fifteen days' period. In these three seasons, therefore, unequivocal forecasts could have been issued. In 1939 the single critical period was within the twenty-one-day interval. In four seasons out of

eleven, therefore, blight followed all the critical periods within twenty-one days. This was not so with the Dutch rules in any single season, unless dates before July were excluded. If we consider July in relation to the temperature-humidity rule, we find that blight followed within fifteen days in four seasons out of ten and within twenty-one days in six seasons out of ten (Table 1a). This is very similar to the results from the Dutch rules. Examination of column 8 shows, however, that fairly good forecasts could have been made every year except in 1932, 1934 and 1937 when there would have been no forecasts.

A comparison of the general results of the application of the two sets of rules indicates that the Dutch rules give rather too many critical periods and the temperature-humidity rules too few. Might not a slight modification of the temperature-humidity rules lead to their wider application? It is possible, for example, that a period of one or two hours of slightly lower relative humidity than 75 % would not check the effect of the two-day period in bringing about the production of conidia. When the weather data available for 1931-9 are re-examined to allow for this, the total number of critical periods is increased from nineteen to twenty-eight, and accurate forecasts can be made of the slight outbreaks in 1934 and 1937 not previously forecasted. The percentage of critical periods within the fifteen-day period, out of the total observed before the outbreak, is, however, only slightly greater in this wider application, i.e. fourteen out of twenty-eight (50 %) instead of eight out of nineteen (42 %), and for the twenty-one-day period sixteen out of twenty-eight (57 %) instead of eleven out of nineteen (58 %). The advantage of a slightly wider interpretation of the humidity rule is therefore negligible.

The important exception of the June outbreak of 1931 may now be considered. Humidity and temperature were both favourable on 28, 30 and 31 May, and on 5, 6, 8, 9, 10 and 11 June, i.e. on nine days out of fifteen. In no other year were there more than four such days in this period. Again, the number of days in May 1931 with the requisite temperature and humidity was six: in other years the number ranged from none to three. If we examine the Dutch rules for the same period there is no such outstanding indication: the number of favourable days before 10 June, the date of outbreak, was only three. There were also three days before this date in 1933 and two in 1929, 1932 and 1935. Also in May 1931 and in six other seasons there was only one favourable day according to the Dutch rules.

It may thus be concluded that from 1929 to 1939 both the Dutch rules and the temperature-humidity rule gave useful indications of blight in South Devon, and that the temperature-humidity rule was slightly more precise and simpler to apply.

APPLICATION OF THE TEMPERATURE-HUMIDITY RULE TO OTHER DISTRICTS

West Cornwall. Conditions in West Cornwall are particularly interesting because the potato crop consists of early varieties put in the ground very early and often dug before blight has appeared in other parts of England.

Limited crop rotation and close planting favour the progress of the disease. It might therefore be expected that the conditions preceding a blight outbreak might correspond less closely to the rules than in South Devon. Investigation has shown that this is not so, but that, as will be seen in Table 2, the rules apply to West Cornwall equally satisfactorily.

Table 2. *Potato blight in West Cornwall 1931-9*

Year	Date of outbreak	Number of critical days preceding outbreak of blight		Remarks
		Up to 15 days	Over 15 days	
1931	12 May	1	0	
1932	30 May	2	0	
1933	7 May	1	1	
1934	16 May	0	0	Very local
1935	—	1	0	
1936	—	0	0	
1937	20 May	1	0	
1938	—	2	0	Crop lifted early
1939	—	0	0	

The data in the table for 1931 and 1932 were prepared from records taken at Gulval, which is in the centre of the early potato area. Early afternoon readings of humidity were not taken after 1932 and the data for the remaining years were obtained from the Daily Weather Map, which gives the minimum temperature at Penzance and the 13 hr. relative humidity at the Lizard. These are less satisfactory, as the minimum temperature is often slightly lower at Penzance than at Gulval, and at the Lizard there is generally a higher humidity. To correct this a minimum of 80% humidity was taken for the table.

The records show that blight followed the first critical periods within fifteen days in three seasons out of the four in which blight occurred in the district. In the fourth season (1933) blight followed thirty-five days after the first critical period and two days after the second. There was no critical period and no blight in 1936 and 1939; and in 1934, 1935 and 1938 the first critical period came too late, most of the crop having been lifted before blight made its appearance.

In 1931 the critical period coincided with the outbreak of blight, which was probably governed by the weather of 28 and 29 April and 5, 6 and 7 May, when the slightly lower minimum temperatures that prevailed on those dates, coupled with the high humidity, were still sufficient to bring about blight. This was also noticed for earlier seasons by Wiltshire (1931).

France. The temperature-humidity rule was tested in France in 1938 by Limasset (1939). Observations at Versailles showed that there was no favourable period until September, the only days following the rules being 26 July, 23 August, and 20, 25, 26 and 27 September. Spread of blight began early in August but was slight; and as was found for Newton Abbot in 1934 and 1937, the method was not successful in forecasting the start of a slight epidemic. As pointed out by Limasset, under such conditions the microclimate determines the extent of the disease in any given locality and

cannot be represented adequately by a single set of observations. At the end of September, when the epidemic became more extensive, the rules could be correctly applied.

Other observers in the Hautes Pyrénées in 1938 found that the outbreak of blight (20 August) followed a favourable period from 15–18 August in which the rules were obeyed (Ministère d'Agriculture, 1939, p. 114).

SUMMARY

A detailed study has been made of the meteorological data recorded at Seale-Hayne Agricultural College, Devon, during the eleven years 1929–39, in relation to outbreaks of potato blight, and it has been shown that the Dutch rules governing the date of the blight outbreak also apply in South-west England. Their practical value as a basis for forecasts is lessened by the fact that favourable days occur which are not soon followed by blight, so that the application of the rules in Devon in every season except 1931 indicated blight earlier than it appeared. During the period in question blight appeared in June only in 1931. Excluding this year and considering only the July and August weather data it was found that blight followed the first critical date within fifteen days in three seasons out of ten and within twenty-two days in six seasons out of ten. The rules provided no explanation of the early outbreak of 1931.

It is difficult to obtain the necessary data for the application of the Dutch rules, and a simpler modification has been devised and called the 'temperature-humidity rule'. The conditions are (1) minimum temperature not less than 50° F. and (2) relative humidity over 75 % for two consecutive days. This rule has been found to give good results in Devon and West Cornwall most seasons. Blight followed the first critical dates within fifteen days in three seasons out of eleven and within twenty-two days in five seasons out of eleven. The data also throw light on the exceptionally early outbreak of 1931. Excluding this year and considering only the July and August weather records it was found that blight followed the first critical period within fifteen days in four seasons out of ten and within twenty-two days in seven seasons out of ten. In the remaining three seasons there was no critical period. This failure to indicate blight was not a disadvantage from the practical point of view because the blight epidemic was so slight in those seasons.

On the whole the temperature-humidity rule is regarded as slightly more useful for blight forecasting than the Dutch rules.

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THE ECOLOGY OF *ERYSIPHE GRAMINIS* DC.

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(With Plate V and 7 Text-figures)

Corn mildew, caused by the fungus *Erysiphe graminis* DC., can assume serious economic proportions in the west of Scotland, when cereal crops are grown for green fodder. It causes some damage on grain crops, but probably develops too late in the growing period to curtail the production of grain very seriously.

Studies on the ecology and biology of *E. graminis* in various countries have given somewhat discordant results, and it is probable that different strains are involved on the same crop in different regions. There are, of course, strains upon various grasses and cereals which will not inter-infect. The strain chiefly used in the present experiments appears to attack only oats; it will not infect wheat. These investigations were planned to acquire information as to the factors responsible for the severity of attack by *E. graminis* in the west of Scotland. They evaluate some aspects of the major factors of climate, soil nutrition and composition of the host plant. Literature on *E. graminis* has been adequately reviewed by Cherewick (1944).

THE EFFECT OF CLIMATE

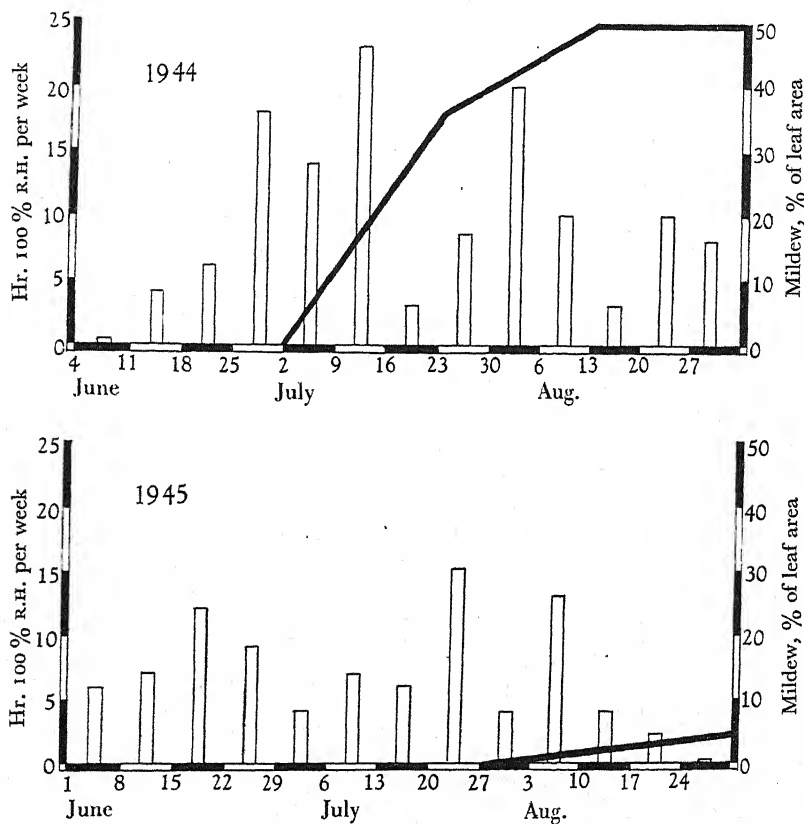
Preliminary correlations of climate and the severity of corn mildew, suggest that the fungus owes more to increase in relative humidity (R.H.) than to increase in summer temperature, in the severity of its attack (Table 1). Records showed, moreover, that the R.H. associated with the heaviest infection of mildew (greenhouse, Table 1), reached 100 % on six days out of the forty-two covered by the preliminary inquiry. The R.H. of the other two sites never attained saturation at 9 a.m., when the readings were taken.

Table 1. *General climatic relations of Erysiphe graminis on oats*

Site	Mildew % of leaf area	During development of disease	
		Av. temp. ° F.	Av. % R.H.
Plant Pathology fields, Auchincruive	20	59	79
Oat trials, Auchincruive	25	69	77
Greenhouse, Plant Pathology Dep.	65	59	88

It is suspected that the disease becomes severe when atmospheric humidity reaches saturation for appreciable periods. That this idea has some foundation in fact is shown by Text-fig. 1, which integrates the number of hours of 100 % R.H. per week with the percentage of leaf area

covered by the fungus. The humidity was computed from a continuous hygrograph record; the infected leaf area was estimated by comparison with 'standard area' diagrams (see Appendix). The year 1944, with a large number of hours of 100 % R.H. per week allowed a development of the fungus to cover 50 % of the leaf area; 1945, with fewer hours of saturation per week, had a much lower infection of about 5 %. These figures refer to the general level of mildew in the oat crops sown round the meteorological station at the Department of Plant Pathology, Auchincruive.



Text-fig. 1. Relation between the intensity of *Erysiphe graminis* and the number of hours 100 % R.H. per week. Vertical columns represent the number of hours per week with saturated atmosphere (left-hand vertical scale). The full black line shows the development of mildew (right-hand vertical scale).

Measurements of spore germination in atmospheres maintained at standard relative humidities confirm this dependence of the fungus upon atmospheric saturation. Conidia from mildewed oat leaves were shaken on to sterile cover-slips, which were stored in sealed glass tubes above solutions containing varying concentrations of calcium chloride. A drop of water containing conidia was placed on a cover-slip in each series, and this was similarly stored over water to prevent evaporation. The whole series was

placed in an incubator at 22° C. Several repetitions were made, and the collected results are given in Table 2. Spores of the fungus *Cladosporium herbarum* are always mixed with those of *Erysiphe graminis* in natural infections, and their differing responses to R.H. are noteworthy.

Table 2. Germination of *Erysiphe graminis* conidia

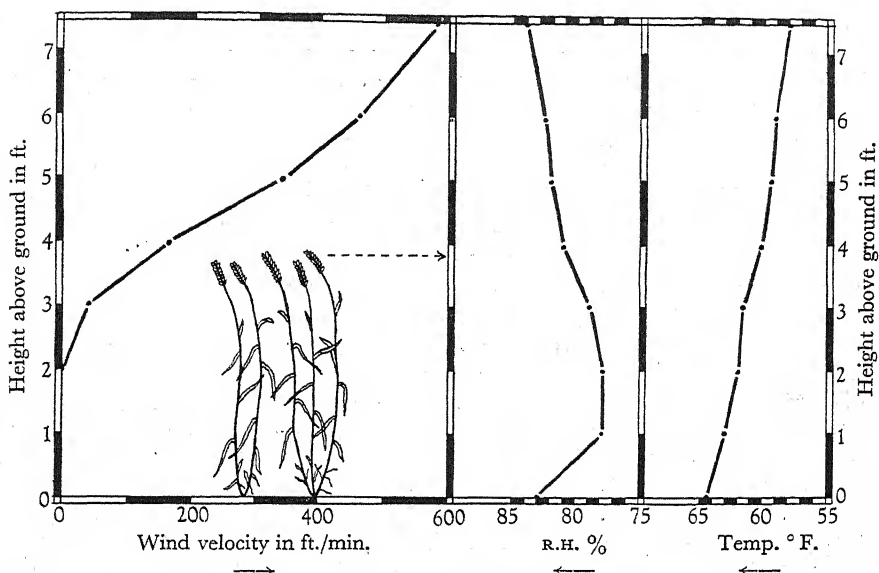
Storage conditions	% R.H.					
	Water	100	90	85	76	66
Maximum percentage germination	8	47	1	0	0	0
<i>Erysiphe graminis</i>						
Germination, <i>Cladosporium herbarum</i>	++	++	+	+	+	0
Solution to give storage conditions	Water	Water	15% CaCl ₂	20% CaCl ₂	30% CaCl ₂	40% CaCl ₂

Spores of the oat strain of *E. graminis* under test germinate much better in air at 100% R.H. (Pl. VA) than in actual water, whilst germination does not take place at relative humidities of 85% or less. Spores of *Cladosporium herbarum* germinate copiously in water and 100% R.H., and grow well at relative humidities down to 76%, but not at 66%. Spores of *Erysiphe graminis* did not grow beyond the stage shown in Pl. VA in these germination tests, but it is noteworthy that *Cladosporium herbarum* grew and produced chains of conidia in water, and over all relative humidities down to 76%.

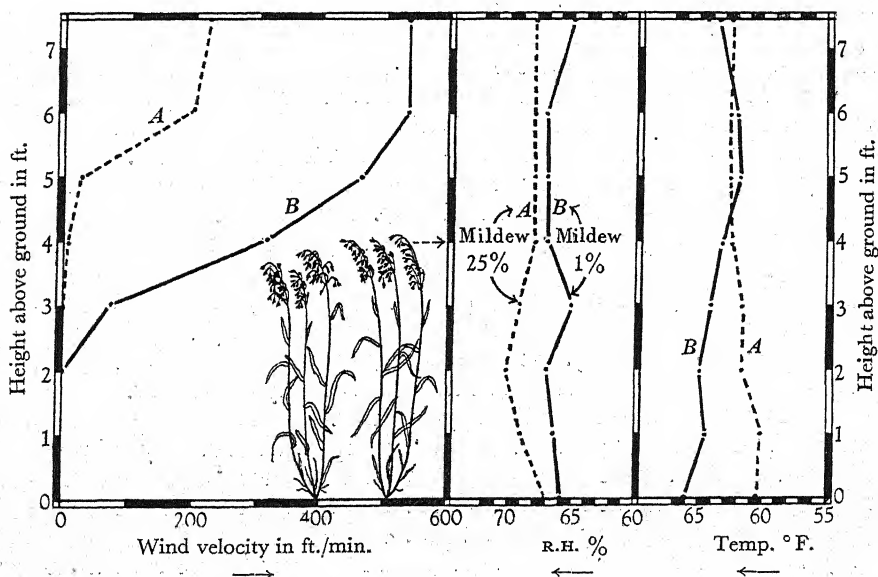
It is reported from Canada (Cherewick, 1944) that conidia of the oat strain of *Erysiphe graminis* will germinate at 100% R.H. and also at 0% R.H. over barium perchlorate. The Scottish strain clearly has not this wide toleration.

E. graminis will attack young oat plants twenty days after germination, if the atmosphere is saturated for sufficient periods. It will also grow upon old leaves, as long as they are green, but ceases to produce conidia when the foliage turns brown. This is apparently not related to the degeneration and loss of the chlorophyll, for no significant germination was obtained when conidia of *E. graminis* were dusted over drops of oat-leaf extract, of green sycamore-leaf extract and anthocyanin-containing red sycamore-leaf extract. Oat-leaf extract, when filtered through filter-paper, gives a cloudy suspension of chlorophyll; sycamore leaves provide a clear, opalescent green or red fluid when similarly prepared. Chlorophyll and anthocyanin therefore appear to be without effect on the germination of *Erysiphe* conidia. It is also interesting that *Podosphaera Oxyacanthae* (DC.) de Bary was found growing on white leaves of hawthorn at Auchincruive in 1945.

Mildew is often found more plentifully towards the base of a cereal crop, than among the upper foliage. This presumably reflects the higher R.H. nearer the ground. It is, indeed, frequently found that humidity is highest near the ground (e.g. in wheat, Text-fig. 2), or in the lower parts of the crop (e.g. oats in Text-fig. 3). These layers presumably reach atmospheric saturation before the air above, and retain it for a longer period. An interesting comparison was possible between two crops of oats grown near one another at Auchincruive in 1946. One crop (*B* in Text-fig. 3) was



Text-fig. 2. Typical meteorological conditions within a wheat crop, 10 Aug. 1945. The wheat had 5 % of mildew in the lowest eighteen inches, and none above; note the highest R.H. near the ground.



Text-fig. 3. Typical meteorological conditions within two neighbouring oat plots at Auchincruive 6 Aug. 1946 (see text).

planted near the top of a low hill, and had an average of 1 % mildew. The other was 300 yards to the south-east, and lay in a slight hollow, to leeward of the hill in relation to the prevailing wind. It experienced much lower wind velocity (*A*, Text-fig. 3), with about 3 % more R.H. than the other crop, and also had 25 % mildew.

It would seem, from general observations, that corn mildew is generally more severe in the west of Scotland than in most parts of England. Heavy attacks occur in all regions, but when I moved from Yorkshire to the west of Scotland I obtained a strong impression that mildew is much more generally severe in the latter region. Data compiled from the Air Ministry's *Monthly Weather Reports* (1938-44) for the various meteorological districts of the British Isles show that the west of Scotland has a large number of rain days per annum, and a slightly higher average R.H. than most regions of England. Differences of average R.H. are not large, but are fairly significant (e.g. p = between 0.05 and 0.02 by t -test when comparing the west of Scotland (83 %) with the midlands of England (78 %)). The west of Scotland, moreover, has significantly higher average monthly humidities from May to August, when cereal crops make most growth, than districts in England. Figures of R.H. during the summer months for the west of Scotland are only exceeded by the north of Scotland, where mildew is also severe.

These field and regional studies all tend to confirm the relation between severity of *Erysiphe graminis* and a high R.H. They also point to the need for a more detailed and comparative estimation of disease intensity between regions.

THE EFFECTS OF MAJOR SOIL NUTRIENTS

Most workers report increasing severity of mildew when nitrogenous manures are added to the soil. Field experiments at Auchincruive in 1945 and 1946 suggest that phosphate reduces the severity of mildew and potash increases it. These experiments were carried out in conjunction with Mr John McFarlan of the Department of Agriculture, West of Scotland Agricultural College. The results are shown in Tables 3 and 4.

They show that both nitrogen and potash tend to make mildew more severe, while phosphate reduces its severity. The effect of nitrogen has been confirmed by adding varying amounts of nitrogen to water cultures of oats (Table 5).

Additions of phosphate to land which is already well supplied with phosphate appear to be without effect upon the severity of mildew, when oats are grown (Table 6). It is probably only the correction of actual phosphate deficiency which will reduce the severity of mildew.

Various practical indications suggest that continued applications of artificial manures have an adverse effect upon the severity of mildew. This can be seen by comparing the plot totals for 'no addition' and 'complete manuring' in Tables 3 and 4. The question has also been tested by solution culture, using two methods:

- (1) Varying the concentration of solution directly (curve *A* in Text-figs. 4, 5 and 6).
- (2) As (1), but the solution renewed every fourteen days (curve *B*).

Table 3. *Soil factors and Erysiphe graminis*, 1945

(Phosphate-deficient soil, Peel Hill, Auchincruive)

Treatment	Mildew, % of leaf area	Plot totals			
No addition	4				
Nitrogen	19				
Phosphate	0.5	Nitrogen	52	No nitrogen	14.5
Potash	9	Phosphate	17.5	No phosphate	49
Nitrogen, phosphate	2	Potash	41	No potash	25.5
Phosphate, potash	1	No addition	4	Complete manuring	14
Nitrogen, potash	17				
Nitrogen, phosphate, potash	14				

Table 4. *Soil factors and Erysiphe graminis on Victory Oats*, 1946

(Soil low in phosphate, Donald's Thorn, Auchincruive)

Treatment	Mildew % of leaf area		Plot totals			
	Block I	Block II				
No addition	22	15				
Nitrogen	27	30				
Phosphate	15	15	Nitrogen	226	No nitrogen	171
Potash	42	25	Phosphate	180	No phosphate	222
Nitrogen, phosphate	40	18	Potash	210	No potash	182
Phosphate, potash	20	17	No addition	37	Complete manuring	55
Nitrogen, potash	33	28				
Nitrogen, phosphate, potash	28	27				

Manures applied at rates per acre, in 1945 and 1946

Nitrogen	3 cwt.	Nitro chalk
Phosphate	6 cwt.	18 % superphosphate
Potash	2 cwt.	60 % muriate of potash

Table 5. *Nitrogen level and Erysiphe graminis on Star Oats*

Culture solution	Mildew % of leaf area average of all leaves
Sachs's + micro-solution: with $\frac{1}{2}$ normal N	7
with normal N	17
with 2 times normal N	25
with 4 times normal N	45

Table 6. *Phosphate level and Erysiphe graminis on Star Oats*

Soil	Original cont. of P_2O_5 mg./100 g. of dry soil	Mildew % of leaf area	
		No addition	+ Superphosphate
Soil A	27	37	34
Soil B	12	57	50
Soil C	0	5	0
(phosphate fixing)			

Each pair of soils was compared separately, and at different times, so that the amounts of mildew recorded are only comparable as between no addition and the application of superphosphate in each case.

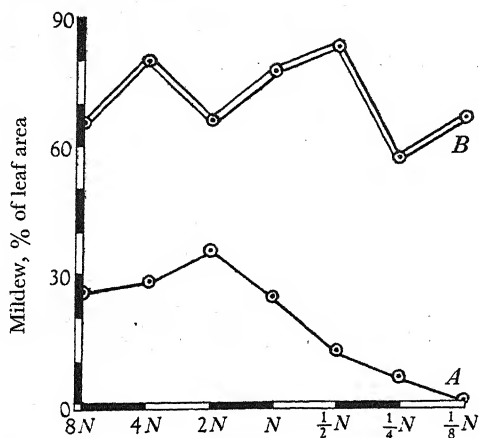


Fig. 4.

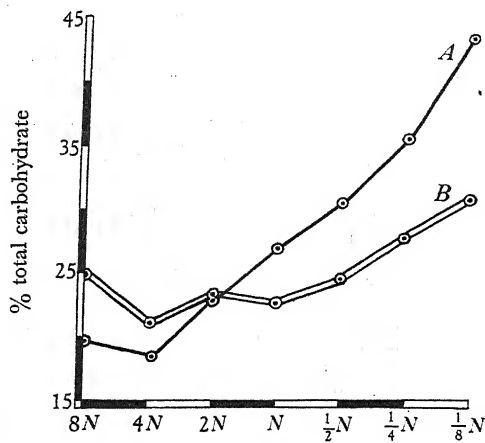


Fig. 5.

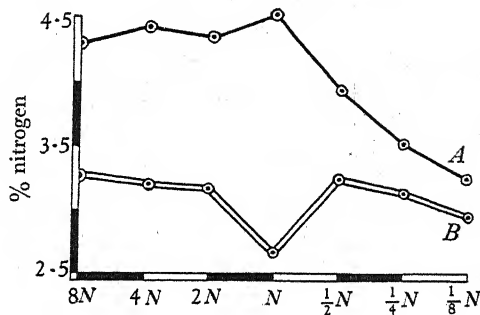
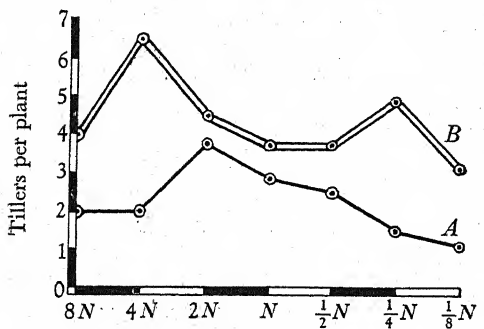
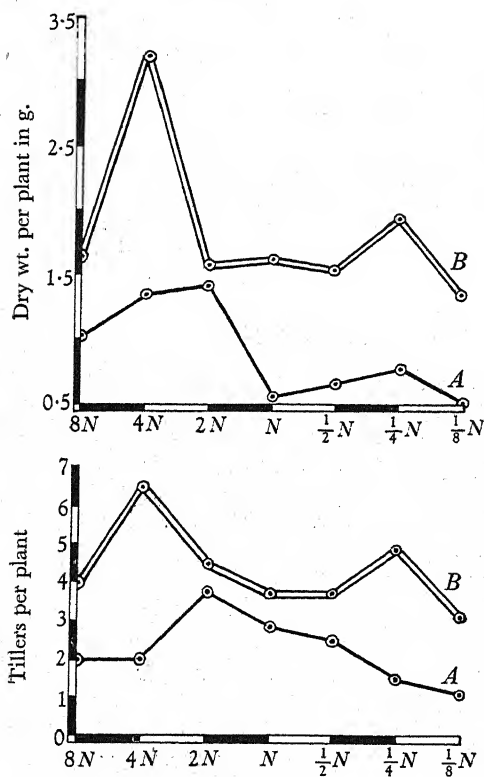


Fig. 6.



Text-fig. 4. Disease incidence of *Erysiphe graminis* at different levels of inorganic nutrition in solution culture. A=original solution retained throughout. B=solution changed every fourteen days. N on the horizontal axis is normal Sachs's solution with micro addition.

Text-fig. 5. Data for dry weight and tillering of Star oats grown at different levels of inorganic nutrition in solution culture. A=original solution retained throughout. B=solution changed every fourteen days. N on the horizontal axis is normal Sachs's solution with micro addition.

Text-fig. 6. Data for total carbohydrate, nitrogen and ash at different levels of inorganic nutrition in solution culture. A=original solution retained throughout. B=solution changed every fourteen days. N on the horizontal axis is normal Sachs's solution with micro addition. Percentages of nutrients are expressed on a dry-weight basis.

Sachs's solution with additions of micro-elements was made up in seven concentrations, from one-eighth normal to eight times normal. Five culture jars were set up for each strength. Results of dry weight and of tillering are given in Text-fig. 5 and of the incidence of mildew in Text-fig. 4. They show that changing the solution every fourteen days (*B*) resulted in increased dry weight and increased tillering, as compared with the retention of the same solution throughout (*A*). Mildew was much more severe in series *B* (Text-fig. 4), where the solution was changed every fourteen days. The incidence of mildew also increased with increasing concentration in series *A* (Text-fig. 4) up to twice the normal concentration. This provides contributory evidence that raising the level of inorganic manuring brings increased incidence of mildew.

THE EFFECT OF COMPOSITION OF THE HOST PLANT

Differences between the amounts of mildew with varying treatment in the last experiment seemed to provide the possibility of a good test as to whether the amounts of carbohydrate, Kjeldahl nitrogen and ash present in the host had any effect upon the severity of mildew.

All the five plants of each treatment were accordingly dried at 98° C. and were subsequently analysed for total carbohydrate by the Willaman and Davidson (1924) method, for nitrogen by Kjeldahl technique, and for ash by incinerating in a muffle furnace. The results are portrayed in Text-fig. 6, which shows that no relation appears to exist between the amounts of carbohydrate and ash and the level of disease (compare with Text-fig. 4). Total nitrogen is low in series *B*, which has severe mildew, and is higher in series *A*, with much less disease. This is rather surprising, in view of the increase in severity of *Erysiphe* with unbalanced nitrogenous manuring. It suggests that the increase of disease by nitrogenous manuring is brought about rather by an indirect effect of the nitrogen upon the anatomy of the plant, than by its amount within the host.

Another method of testing consists in growing plants under varying lengths of day. It was noticed that spring-sown wheat being grown under eight-hour day conditions developed mildew, whereas the same crop under normal illumination did not do so, nor did autumn-sown wheat under any condition of illumination in 1945. This material was also examined for total carbohydrate, nitrogen and ash, with results set forth in Table 7. The strain of mildew was not that used in the foregoing experiments, but the results are nevertheless useful. They show very little difference in carbohydrate content between the four treatments, but there is more ash and also more nitrogen in the plants which developed mildew. The association of higher nitrogen with severe disease is in contrast with the results of the last experiment, and it was thought that the higher nitrogen might reflect the delay in ripening of the spring-sown, short-day plants. That phenology is not the whole explanation of attack by mildew appeared in 1946, when the disease again developed on short-day oats and wheat, but not so severely on the plants grown with normal length of day, except that infection of the

wheat became more general in August. This appearance of the disease occurred in the early spring, when the autumn-sown wheat had leaves only a few inches long. Mildew is also recorded on wheat in June and on wheat and oats in August. The oats had green leaves in both short-day and long-day settings in August, so there is here no question of ripeness preventing attack by mildew. The collective results shown by Text-figs. 4 and 6 and Tables 7 and 8 do not furnish any correlation between the severity of attack by *Erysiphe graminis* and the major constituents of the host.

Table 7

		Date of fig.	Height ft. in.	Total %		% total carbo- hydrate in leaves	% ash	% N
				Total d.w. grams	% mildew			
LD AS	Sq. Master	21 June	3 2	13.64	0	31.43	6.25	0.78
	White Victor	22 June	3 3	10.55	0	31.45	7.70	0.72
	Als	24 June	3 1	12.98	0	35.78	3.43	0.54
LD SS	Sq. Master	29 June	2 10½	13.60	0	32.91	6.09	0.77
	White Victor	30 June	2 9	9.53	0	41.46	6.52	0.59
	Als	4 July	2 8	12.00	0	44.50	8.40	0.59
SD AS	Sq. Master	18 July	2 3	9.26	0	31.45	3.79	1.01
	White Victor	20 July	2 3	6.21	0	39.03	9.40	1.19
	Als	20 July	1 11	7.16	0	33.03	8.21	1.15
SD SS	Sq. Master	*	10	2.80	5	38.59	11.39	1.28
	White Victor	*	11	2.71	16	41.43	9.77	1.47
	Als	*	7	6.43	2	32.17	10.37	1.19

Samples for analysis were taken 20 August 1945

* Did not flower

Table 8

		Date of flg	Height ft. in.	% solids	% mildew			% total carbo- hydrate	% ash	% N
					10/3	11/6	5/8			
Star oats	LD SS	16 July	2 3	23.5	—	0	0.5	41.6	10.0	2.48
	SD SS	—	11	21.7	—	0	7	42.0	8.2	3.84
Atle wheat	LD AS	24 June	2 0	27.1	0	0	5	39.6	7.9	1.93
	SD AS	—	1 6	24.9	10	5	5	42.0	4.6	2.17
White Victor wheat	LD AS	24 June	2 0	29.1	0	1	40	38.9	7.9	2.25
	LD SS	15 Aug.	1 10	22.3	—	0	1.5	40.9	7.6	2.00
	—	SD AS	—	1 9	25.3	15	22 28	36.2	11.9	2.54
	—	SD SS	—	6	19.5	—	0 30	28.6	12.0	3.65

Samples for analysis were taken 5 August 1946

LD Long day (normal variation in length of day)

SD Short day (eight hours exposure to light)

AS Autumn sown (Table 7) 23 Sept. 1944, (Table 8) 14 Nov. 1945

SS Spring sown (Table 7) 28 Feb. 1945, (Table 8) 12 Apr. 1946

— Not sown on 10 March 1946

It is also interesting that mildew on oak, wild cherry and rose does not appear to be correlated with the amounts of total carbohydrate, or with the content of reducing sugars (Table 9). These results are from material taken for analysis on 11 August 1936.

Table 9

	Solids % of fresh wt.	Total carbohydrate % of dry wt.	Reducing sugars % of dry wt.
A. <i>Microsphaera Alni</i> on oak (<i>Quercus robur</i>), Dean Nick, Huddersfield			
Healthy young leaves	29.25	38.93	33.07
Mildewed young leaves	34.57	14.71	13.65
Healthy old leaves	41.70	13.45	5.27
B. <i>Podosphaera Oxyacanthae</i> on wild cherry (<i>Prunus padus</i>), Dean Nick, Huddersfield			
Healthy young leaves	28.74	19.85	17.54
Mildewed young leaves	28.29	19.52	19.52
Healthy old leaves	32.28	10.00	10.00
C. <i>Sphaerotheca pannosa</i> on cultivated rose, Huddersfield			
Healthy young red leaves	24.5	34.21	25.26
Healthy young green leaves	36.4	25.78	24.37
Green-red leaves with mildew	30.0	26.62	24.93
Green-red leaves; mildew removed	28.7	20.12	20.12
Healthy old leaves, 1	37.9	16.88	16.88
Healthy old leaves, 2	26.5	30.95	29.29

SUMMARY

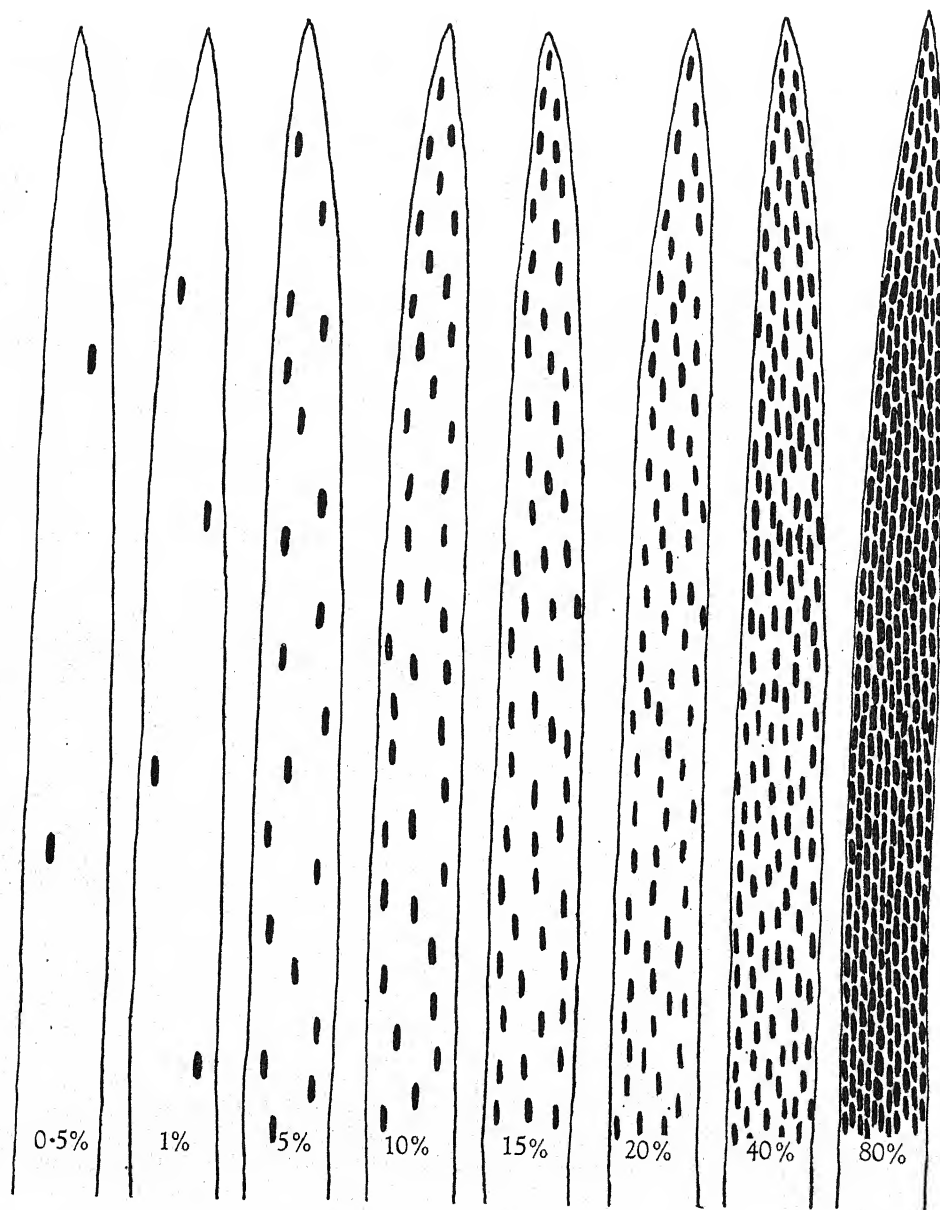
A strain of *Erysiphe graminis* which attacks oats in the west of Scotland has been mainly used in the present investigation. Conidia germinate much better in a saturated atmosphere than they do in water. Germination is low at 90 % R.H. and apparently does not take place at lower values of R.H. Spores of *Cladosporium herbarum* which accompany those of *Erysiphe graminis* will grow and fruit in water and at humidities down to 76 %, but not lower.

Climatic correlations suggest that the severity of the disease in the field is related to the degree of saturation of the atmosphere. Regional and field studies support this view. Severity of the disease appears to owe much more to the inorganic nutrition than to the gross composition of the host. Practical control of the disease in the west of Scotland lies in the avoidance of excess nitrogen and potassium in the soil, the correction of any deficiency of phosphate, and the avoidance of heavy and frequent application of artificial manures.

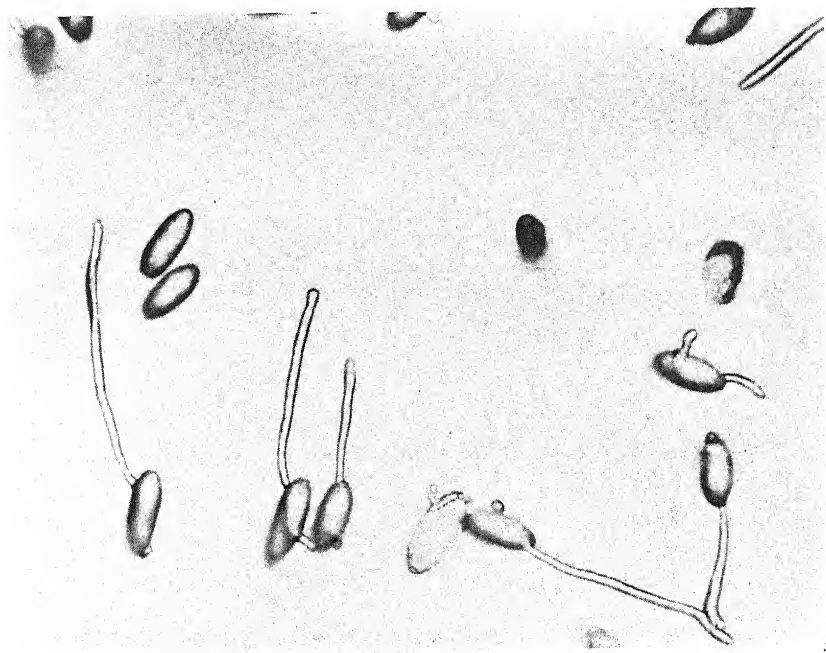
The writer wishes to express his grateful thanks to members of his staff at the Department of Plant Pathology, Auchincruive, for their general assistance, and to Mr H. F. Dovaston for the photomicrographs of Plate IV. Mr John McFarlan has maintained valued collaboration with the field experiments, and the determinations of Table 9 were made in 1937 with the help of Mr A. Broadbent of Huddersfield.

APPENDIX

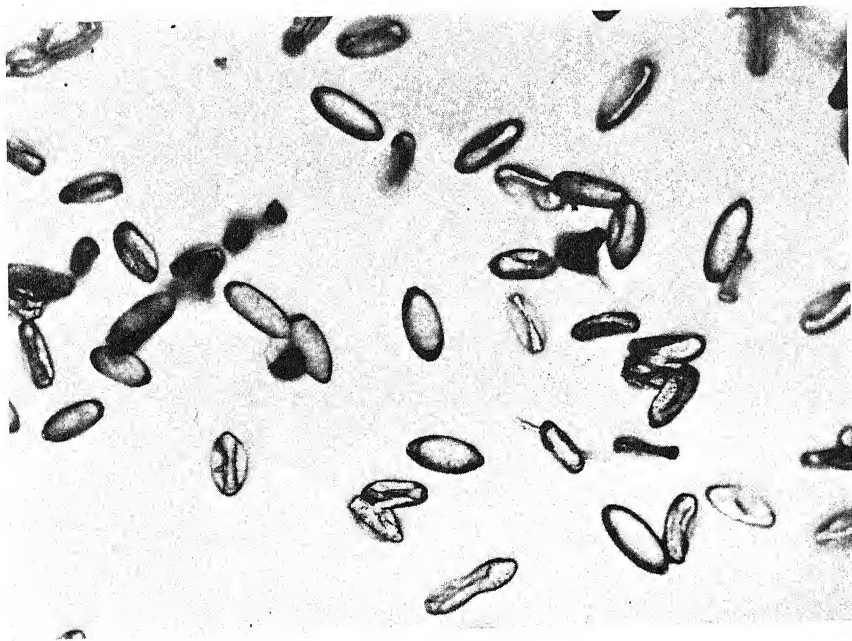
In this paper the severity of mildew has been expressed as a percentage of the total leaf area of the host which was covered by the fungus. This has been accomplished conveniently by comparing all leaves of the plant with 'standard area' diagrams (Text-fig. 7). An average of all these readings gave



Text-fig. 7. The 'standard area' diagrams used for the determination of percentage leaf area affected by *Erysiphe graminis*.



A



B

the disease measurement for the plant as a whole. In field measurements it was found adequate to assess the disease intensity at the base, middle and top of the crop, the average of all three being the reading for the sampling station. Four stations were estimated on plots $\frac{1}{40}$ acre in area, nine in $\frac{1}{20}$ acre plots, whilst twenty sampling stations were measured in each field, when it was necessary to make more widespread estimations.

The 'standard area' diagrams were made by spacing ovoid dots upon a leaf-shaped area, the dots having standard percentages of the leaf area. They thus provide a standard of comparison for different persons, for different regions and for different times. It does not seem to matter very much that the standard areas can never equal those of any leaf in actual shape and distribution; the human eye detects fairly readily the similarity of distribution frequency and pattern.

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- CHEREWICK, W. J. (1944). Studies on the biology of *Erysiphe graminis* DC. *Canad. J. Res.* XXII, 52-86.
WILLAMAN, J. J. & DAVIDSON, F. R. (1924). Some modifications of the picric acid method for sugars. *J. agric. Res.* XXVIII, 474-88.

EXPLANATION OF PLATE V

- A (above). Germination of conidia of *Erysiphe graminis* in air at 100 % R.H. B (below). Conidia in air at 90 % R.H. Only one spore has germinated, and many spores are shrivelled.

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SPONTANEOUS VARIATION IN *PENICILLIUM* *NOTATUM* STRAIN N.R.R.L. 1249 B21

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(With Plates VI and VII and 1 Text-figure)

Since certain strains of *Penicillium notatum* had been reported to be very variable and much variation had been observed in the cultures used for the commercial production of penicillin, it was decided to investigate this phenomenon. The strain examined most thoroughly was N.R.R.L. 1249 B21, which was distributed by the Northern Regional Research Laboratories, Peoria, Illinois, and has been widely used for commercial production by the surface culture method. It was derived by successive selections from the original Fleming strain. Raper and Alexander (1945) have described this strain and given an account of its history. They reported the occurrence of paler, less highly sporulating variants and of darker, more heavily sporulating variants. The present investigations were begun before the publication of Raper and Alexander's paper, and where the observations coincide the results obtained are in agreement with those of Raper and Alexander. Variants showing differences in sporulating capacity have been obtained by single conidial platings and by streaking from mycelial patches on old cultures. The poorer sporulators were found to be the higher penicillin yielders up to a certain limit. Very poor sporulators, however, seem to be very poor yielders of penicillin as reported by Raper and Alexander (1945).

It is the purpose of this paper to deal in greater detail with the occurrence of variations affecting sporing capacity, with a view to elucidating the cause or causes of the variation.

METHODS

Streaking from old cultures

Variants were obtained from patches of mycelial growth overgrowing the normal conidial type on old cultures. By streaking and finally inoculating on to plates of plain agar it was usually possible to obtain single hyphal isolations of these types. These gave apparently pure cultures of mycelial habit. Cultures obtained in this way I have called 'mycelial types'. Similar 'mycelial types' were also obtained by conidial platings of old cultures.

Single conidial isolations

Variants were also obtained by plating out suitable dilutions of conidial suspensions taken from cultures of various ages. The conidial suspensions were made in physiological saline and detergent (0.1 % calsolene oil). The suspensions were well shaken to break up chains of conidia and filtered through absorbent cotton under sterile conditions. This removes pieces of mycelium and clumps of conidia. The density of a conidial suspension was

found by making haemocytometer counts and from this suitable dilutions were estimated and plated. The haemocytometer observations also permitted a check on the presence or not of clumps of conidia. If such were observed the suspension was shaken and re-filtered. This was very seldom necessary, the conidia being usually well separated. A small amount (0.2 c.c.) of the required spore dilution was spread over the surface of an agar plate with a spreader made of bent glass tubing. It was preferred to spread the spores over the surface of the agar rather than to mix them in cooled melted agar and then pour them, since the former method gave a more regular germination of spores which facilitated a comparison of the single spore colonies.

With some exceptions the medium used was 3 % malt extract with 2 % agar. On this medium the types of variants studied were clearly differentiated from each other and the parental type.

PRESENT OBSERVATIONS

An ampoule of *Penicillium notatum* N.R.R.L. 1249 B21 (circulated by the Northern Regional Research Laboratories, Peoria, Illinois), was opened and subcultured. The subculture was transferred to plain agar and single hyphal isolations made. These proved to be of two types, indicated here as T1 and T2. Type 1 (probably the parental 1249 B21 type) was paler and less heavily sporulating than T2. It is not known whether the colour difference between the two types is entirely due to difference in conidia production or not. T2 also differed from T1 in that it produced less yellowing of the medium.

On malt agar T1 gave a smooth velvety growth, pea green (Pl. 47, Ridgway colour chart) on the eighth day. T2 gave a similar type of growth, sage green (Pl. 47) on the eighth day. On the modified Czapek agar used by Raper and Alexander, when three colonies were inoculated on one plate, the edge of the plate was reached by the tenth day. T2 showed a rather flat velvety growth with a few shallow radial furrows. T1 was similar to T2 with slightly more pronounced furrows. The colours on the tenth day according to the Ridgway colour chart were artemisia green (Pl. 47) at the outside, shading to Hathi grey (Pl. 52) in the centre for T1, and artemisia to celandine green at the edge, shading to dark olive grey in the centre for T2. In both cases the colony reverse was yellow.

Colonies of each type were more uniform and more distinct from the other type on malt than on Czapek agar.

At first it was not known whether T1 or T2 was the standard 1249 B21 type. However, according to the description given by Raper and Alexander, T1 would appear to correspond to the original type, T2 probably being a variant derived from it.

Conidial platings were made from the original single hyphal isolates, and single conidium cultures were obtained by transferring a piece of agar containing a single germinated conidium on to an agar slant under the dissecting microscope. Spores from the single spore cultures were in time plated out and in this way data were obtained concerning the number of variant colonies given by single hyphal and single conidium cultures.

Table 1. *Production of pale and dark variants by H.T. (single hyphal) and S.S. (single conidium) cultures of T1 type*

	Total colonies	Dark	% dark	Pale	% pale	Other types	% other types	Total variants	% variants
*H.T.: 11 days	179	1	0.6	3	1.7	—	—	4	2.2
23 "	775	10	1.3	6	0.8	5	0.6	21	2.7
28 "	243	5	2.1	1	0.4	—	—	6	2.5
42 "	134	2	1.5	—	—	—	—	2	1.5
10 "	621	4	0.6	17	2.7	—	—	21	3.4
10 "	534	4	0.7	5	0.9	—	—	9	1.7
18 "	510	2	0.4	13	2.5	3	0.6	18	3.5
Total	2996	28	0.9	45	1.5	8	0.3	81	2.7
*S.S.: 13 days	401	7	1.7	11	2.7	—	—	18	4.5
4 "	696	—	—	5	0.7	—	—	5	0.7
21 "	253	5	2.0	—	—	—	—	5	2.0
10 "	1117	4	0.4	18	1.6	—	—	22	2.0
13 "	1092	7	0.6	21	1.9	—	—	28	2.6
Total	3559	23	0.6	55	1.5	—	—	78	2.1
Total H.T. and S.S. cultures	6555	51	0.8	100	1.5	8	0.1	159	2.4

Table 2. *Production of pale and dark variants by H.T. (single hyphal) and S.S. (single conidium) cultures of T2 type*

	Total colonies	Dark	% dark	Pale	% pale	Other types	% other types	Total variants	% variants
*H.T.: 10 days	324	1	0.3	—	—	—	—	1	0.3
10 "	2268	—	—	—	—	—	—	—	—
10 "	147	6	4.1	—	—	—	—	6	4.1
* 11 "	529	2	0.4	—	—	—	—	2	0.4
18 "	626	—	—	—	—	—	—	—	—
28 "	626	—	—	4	0.6	—	—	4	0.6
* 11 "	560	—	—	4	0.7	—	—	4	0.7
42 "	239	—	—	—	—	1	0.4	1	0.4
* 42 "	199	2	1.0	1	0.5	—	—	3	1.5
Total	5518	11	0.2	9	0.2	1	—	21	0.4
S.S.: 4 days	493	—	—	—	—	—	—	—	—
10 "	2154	—	—	—	—	—	—	—	—
13 "	782	—	—	22	2.8	—	—	22	2.8
* 13 "	468	6	1.3	1	0.2	—	—	7	1.5
21 "	361	3	0.8	1	0.3	—	—	4	1.1
* 29 "	648	4	0.6	5	0.8	—	—	9	1.4
* 29 "	199	—	—	—	—	—	—	—	—
Total	5105	13	0.3	29	0.6	—	—	42	0.8
Total H.T. and S.S. cultures	10,623	24	0.2	38	0.4	—	—	63	0.6

* Obtained from cultures used in production at the I.C.I. plant in Trafford Park.

The results obtained from cultures of T1 type are shown in Table 1 and those from darker types in Table 2. These tables include a number of dark and light selections obtained from cultures used in production at the I.C.I. plant in Trafford Park. The cultures within one group were not identical in appearance and it is possible that they differed by certain genetic modifying factors. Table 1 shows the results obtained by plating seven single hyphal and five single conidium cultures of Type 1. There were no statistically significant differences between platings from the single hyphal and single

conidium cultures. There were 0.8 % of darker variants, 1.5 % of paler variants and 0.1 % of other variant types, 2.4 % in all.

The darker types (Table 2) gave only 0.6 % of variants, 0.2 % of darker variants and 0.4 % of paler variants. The cultures of T1 gave approximately four times as many variants as those to T2. This spore plating method for detecting variants might be expected to favour the higher sporulating types but since this would tend to increase the number of darker variants and decrease the number of paler variants recorded in both T1 and T2, it is possible that the darker types are actually more stable than the paler ones. It is also possible that the cultures included in Table 2 are not homogeneous with respect to rate of variation, some being more stable than others. Very stable strains have been obtained from T1. On one occasion a very dark heavily sporulating type giving excessive yellowing of the medium was obtained from a culture of T1. This proved to be very stable and paler variants derived from it were also relatively stable.

The preliminary investigations showed a remarkable degree of uniformity both in the proportions of mutants and in their appearance. It seemed possible therefore that the greater part of the variability observed in this strain might be due to the constant occurrence of a particular type of change rather than to random variations of different origin. In order to test this hypothesis T1 was studied more intensively.

Analysis of Type 1 variants

From a plating of T1, a standard T1, a pale variant T1a, and a dark variant colony T1b, were streaked and finally single hyphal isolations were made. Conidia from these isolates were plated and single conidium isolations were made. It was found that T1a, gave a still paler variant type, T1a₂ and also variants resembling T1 and T1b. This seems to indicate that changes in sporulating capacity occur in steps since T1a gives a still paler variant T1a₂ and that these changes are reversible since T1a gives a type closely resembling T1. The results from seven single conidium cultures of T1 are given in Table 3, and from eleven single spore cultures of T1a, in Table 4. It will be noticed that every culture gave colonies of a paler type, T1a and that all except two gave a darker type, T1b. The percentages of these variants were remarkably constant from one culture to another, with the exception of S.S. 3 which was recorded as having a visible pale sector and which gave a higher percentage of pale variants than its sister cultures. The average percentage of T1b variants was 0.4 and of T1a, excluding the culture with a visible pale sector, 2.2. The percentage of variants of all types was 2.7, excluding S.S. 3. Single conidium cultures of the pale type T1a gave 0.9 % of still paler variants, T1a₂, 1.7 % of variants resembling T1 and 0.3 % of variants of T1b type, as shown in Table 4. Again the percentages of variants of the different types were very constant among the offspring of the sister cultures. Only in one culture, which had been recorded as having a visible green sector, was there any striking deviation from the average percentages. The average percentage of total variants, excluding the culture with a sector, was 3.0, not significantly different from the 2.7 observed in the case of T1. Only four cultures of

Table 3. *Production of dark (T₁b) and pale (T₁a) variants by sister single conidium cultures of T₁ type*

Culture	Total colonies	T ₁ b variants	% T ₁ b	T ₁ a	% T ₁ a	Others	%	Total variants	% variants
S.S.: (1) 12 days	967	—	—	13	1.3	—	—	13	1.3
(2) " "	553	1	0.2	12	2.2	1	0.1	14	2.5
(3) " "	1100	4	0.4	97	8.8	—	—	101	9.2
(4) " "	1064	4	0.4	26	2.4	1	0.1	31	2.9
(5) " "	353	—	—	4	1.1	1	0.3	5	1.4
(6) 19 "	486	9	1.9	11	2.3	—	—	20	4.1
(7) " "	504	2	0.4	26	5.1	—	—	28	5.6
(8) " "	562	4	0.7	6	1.6	—	—	10	1.8
Total	5589	24	0.4	195	3.5	3	0.1	222	4.0
Total excluding S.S. (3)	4489	20	0.4	98	2.2	3	0.1	121	2.7

* Recorded as having a visible pale sector.

Table 4. *Production of dark (T₁ and T₁b) and pale (T₁a₂) variants by sister single spore cultures of T₁a type*

	Total colonies	T ₁ variants	% T ₁	T ₁ b variants	% T ₁ b	T ₁ a ₂ variants	% T ₁ a ₂	Total variants	% total
S.S.: (1) 12 days	485	3	0.6	1	0.2	8	1.7	12	2.5
(2) " "	355	5	1.4	—	—	3	0.9	8	2.3
(3) " "	1049	12	1.1	2	0.2	6	0.6	20	1.9
(4) " "	833	11	1.3	2	0.2	9	1.1	22	2.6
(5) " "	1024	10	0.9	1	0.1	13	1.3	24	2.3
(6) 19 "	330	3	0.9	1	0.3	8	2.4	12	3.6
(7) " "	474	11	2.3	4	0.8	1	0.4	16	3.4
(8) " "	970	18	1.9	2	0.2	5	0.5	25	2.6
(9) " "	825	159	19.3	3	0.4	5	0.6	167	20.2
(10) " "	911	37	4.1	8	0.8	6	0.7	51	5.6
(11) " "	429	8	1.9	1	0.2	6	1.4	15	3.5
Total	7685	277	3.6	25	0.3	70	0.9	372	4.8
Excluding S.S. (9)	6860	118	1.7	22	0.3	65	0.9	205	3.0

* Recorded as having a visible dark sector.

Table 5. *Production of darker (T₁b₂) variants by cultures of T₁b type*

Culture	Total colonies	T ₁ b ₂ variants	% T ₁ b variants
H.T. (42 days)	1029	—	—
S.S. (1) (14 days)	691	1	0.1
S.S. (2) (14 days)	981	28	2.9
S.S. (3) (14 days)	909	—	—
Total	3610	29	0.8

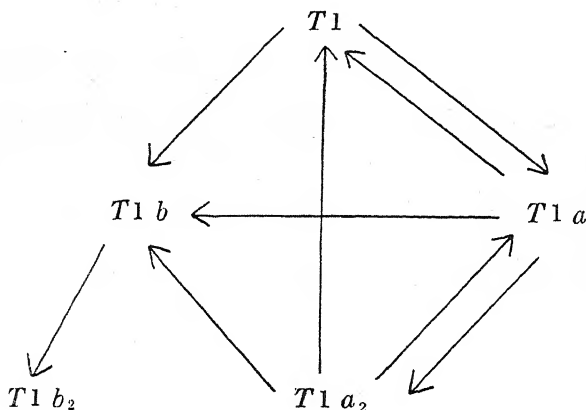
Table 6. *Production of darker (T₁a, T₁ and T₁b) variants by cultures of T₁a₂ type*

Culture	Total colonies	T ₁ a variants	% T ₁ a	T ₁ variants	% T ₁	T ₁ b variants	% T ₁ b	Total variants	% variants
S.S. (1) 40 days	51	3	5.9	3	5.9	2	3.9	8	15.7
S.S. (2) 11 days	229	32	14.0	6	2.6	7	3.1	45	19.7
Total	280	35	12.5	9	3.2	9	3.2	53	18.9

T₁b were tested (Table 5). Two of them gave no variants and the other two gave variants of a still darker type, T₁b₂. The average percentage of these mutants was 0.8 % but all except one came from one culture so this

percentage may be higher than that which would be obtained if more cultures were tested. The darker variant $T1b_2$ has not been further investigated.

Two cultures of type $T1a_2$ have been plated and each gave variant colonies of $T1a$, $T1$ and $T1b$ types. $T1a_2$ appears to be the most unstable type so far encountered since it gave an average of 18.9% of variant colonies. However, since $T1a_2$ produces very few conidia, variants with greater sporulating capacity would be expected to produce more conidia in proportion to the amount of mycelium present. Hence the conidial plating method of testing variation might be expected to exaggerate the



Text-fig. 1. Variation of $T1$ and derivatives.

actual variation. However, sectoring was more frequent for $T1a_2$ than for the other types, therefore it is probably actually less stable than the other members of the series, although probably not to the extent indicated by the percentage of variant colonies obtained.

The production of variants by the different types is illustrated in Text-fig. 1.

In discussing the tables, it has been assumed that the variants occurring in different cultures were similar variants.

An attempt was made to see how far these variants of similar appearance, occurring regularly in different single spore cultures were identical. Streaks were made from variant colonies. Conidial suspensions were made from these streaks and inoculations were made at three places on an agar plate as follows, using the paper disc method of inoculation devised by Dr P. H. Gregory. Two small sterile filter paper discs were immersed in the spore suspension and placed side by side on the agar plate. Two discs from a suspension made from a similar type of different origin were placed at a second position and one disc from each suspension was placed at the third position. Variants of $T1b$ type arising from four different $T1a$ type cultures were tested against a variant of $T1b$ type arising directly from $T1$. In some cases two different colonies from the same type were tested. In

addition, two $T1b$ cultures arising in two different single conidium cultures of $T1$ type were tested against the control.

In all these tests the three colonies on one plate were identical in appearance (see Pl. VI, fig. 3).

Three variants of $T1$ type from three different single spore cultures of $T1a$ type were similarly tested and gave identical colonies on each plate. See (Pl. VI, fig. 4).

Variants of $T1a$ type obtained from four different single conidium cultures of $T1$ type were combined with a $T1a$ type from a fifth single conidium culture. Mass inoculations were used instead of spore suspensions because of the reduced sporulation in the type. The five cultures tested appeared identical (see Pl. VI, fig. 5).

Variants of $T1a_2$ from four different single conidium cultures of $T1a_1$ type tested in the same way appeared to be identical (Pl. VI, fig. 6).

This method, of inoculating cultures of similar appearance side by side, was used, as being the most stringent test of identity available, in the absence of sexual reproduction. Besides affording the possibility of comparing the cultures, in conditions as nearly as possible identical, it also permits of heterokaryon formation at the line of junction of the two types. The use of heterokaryons is at present the only possible test for allelism in *Fungi imperfecti*. When two different mutants form a heterokaryon it often happens that the mutation in each locus is recessive to its allele on the other nucleus, so that the heterokaryon is different in appearance from its two components. If, for example, two $T1a_2$ types of different origin inoculated side by side gave a green streak at their line of junction it could be deduced that the two types, while phenotypically similar, were genotypically different. However, the absence of such an effect does not prove that they are identical although it is in accordance with such a view.

Description of $T1$ variants

Macroscopic. A description is given of the variants on malt agar which was used as the principal medium and also on the modification Czapek agar used by Raper and Alexander (1945). The various types in the $T1$ series are most clearly differentiated on malt agar on which they give a smooth velvety growth. $T1$ and $T1b$ show a completely flat growth but $T1a$ shows very shallow radial furrowing, and $T1a_2$ a more distinct radial furrowing.

The colours of the types according to Ridgeway's colour chart are as follows:

Type	8 days on malt	11 days on malt	10 days on Czapek-Dox
$T1b$	Sage green 29''', Pl. 47	Pea green 29''', Pl. 47, shading to celandine green 33'''b, Pl. 47	Celandine 33''' through artemisia 33''', Pl. 47, to deep olive 23''' or mouse grey 15''', Pl. 51
$T1$	Pea green 29''', Pl. 47	Court grey 29''', Pl. 47	Artemisia 33''', Pl. 47, at edge shading to Hathi grey 35''' or storm grey 35''', Pl. 52, in centre
$T1a$	Greenish glaucous 33''', Pl. 41	Greenish glaucous 33''' to yellowish glaucous 25''', Pl. 41	
$T1a_2$	Sea-foam yellow 25'', Pl. 31	Sea-foam yellow 25'', Pl. 31	

It will be noticed that colour differences can be observed among the different types on malt agar. On Czapek agar, however, the colours are the same for T_1 , T_1a , T_1a_2 , but the central paler regions differ in size, being largest in T_1a_2 and smallest in T_1 . The differences in macroscopic appearance seem to be due to the fact that $T_1b \rightarrow T_1 \rightarrow T_1a \rightarrow T_1a_2$ form a series of types tending to spore later and less freely.

Microscopic. Preparations were made by fixing portions of mycelium in formol-alcohol for a few minutes, staining in chlorazol black E (saturated solution in 70 % alcohol), rinsing in 70 % and mounting in gum chloral. Chlorazol black was used as a fungal stain by Armitage (1944). The use of gum chloral as a mountant was suggested by Dr P. H. Gregory. It has an advantage over balsam and gum damar for this material in that dehydration and clearing in xylol is eliminated. Hence a greater number of penicilli are left, comparatively undisturbed. It is not known how long such preparations will last but they have been kept for six weeks without appreciable fading. The material was taken from nine-day cultures except in the case of T_1a_2 . (In this type no penicilli could be found in nine-day cultures so mounts were made from 26-day old cultures.)

T_1 . Raper and Alexander (1945) have given a detailed description of the conidial apparatus of 1249 B21 and it is therefore unnecessary to repeat this here. So far as I can determine, T_1 corresponds to 1249 B21 and the description given for this strain holds for T_1 . Metulae vary from one to four in number, sterigmata from one to five with three as the most frequent number and a certain number of irregular penicilli are present (Pl. X, fig. 8).

T_1b (Pl. VII, figs. 7, 11) forms more conidia than T_1 and this is correlated with differences in the number of sterigmata and in the number of conidia to be found on one sterigma. Thus the most frequent arrangement of metulae was in groups of four as compared with three in T_1 . Some sterigmata were observed with chains of eight conidia attached whereas the greatest number of conidia attached to one sterigma in T_1 was six. It is realized that the actual number of conidia observed in the chains is likely to be affected by the mounting process but it is felt that the observations give a fair representation of the relative lengths of chains in the different types.

T_1a_1 . In T_1a_1 (Pl. VII, fig. 9) the greatest number of sterigmata observed had only one conidium and the longest chains recorded consisted of only four conidia. Most frequently only one sterigma was present, but perfectly regular penicilli with groups of four sterigmata were observed. However, irregular penicilli were much more frequent in this type than in the two preceding types; T_1b had 1/30 irregular penicilli, T_1 , 5/42 and T_1a_1 14/36.

The irregularities consisted chiefly in the formation of secondary metulae and in a spreading in the position of the sterigmata. The lower-sporulating types tend to have much less compact penicilli than the normal and the various abnormalities seem to be related to this tendency.

T_1a_2 (Pl. VII, figs. 10, 12) shows a still further reduction in sporulation capacity than T_1a . More penicilli consisting of only one or two sterigmata

were present than in *T1a*. A characteristic of this variant is that the sterigmata are often flattened. The variation in spore size is much greater than in the other types.

Mycelial types. As previously described, patches of mycelial growth frequently occur on old cultures of *P. notatum*. Such patches have been observed on cultures started from a single conidium and therefore originating from one nucleus. A number of *mycelial* types have been obtained from single conidium cultures by streaking and finally making hyphal tip inoculations. Several such cultures have been isolated from single spore cultures of similar type. These cultures differ from each other in general appearance, in the amount of pigment produced and in colony shape but they are all alike in that they rarely revert to the conidial form. The change from the conidial to the mycelial habit appears to be essentially irreversible. Most mycelial types produce some conidia and it has twice been possible to observe that these conidia are formed on greatly reduced, almost abortive penicilli. However, when these conidia are plated out they produce colonies of mycelial type only. In other characteristics, such as colony shape, the mycelial types are subject to variation. All the mycelial types tested by the surface culture method have been found to be poor yielders of penicillin: this is in accordance with the results of Raper and Alexander. They did not distinguish between mycelial types which could not revert to conidial types and very poor sporulating types which could throw higher sporulating types but it is probable that their 'g' and 'M' types are mycelial types in the sense of this paper. Mycelial types have been obtained from both *T1* and *T2* strains. It is probable that mycelial patches may differ in frequency and extent in different strains but few quantitative data have been obtained on this point.

Mycelial types can also be obtained by single conidium isolations from old cultures. One particular mycelial type with a spiky transparent type of growth has been obtained in this way from four different single spore isolations of *T1* and from one of *T2*. One mycelial type, obtained on an old *T1* culture, after continuing unchanged through a number of mass transfers eventually gave a sector of this peculiar transparent type.

DISCUSSION

The evidence presented indicates that *T1* and its derivatives are subject to frequent variation of a particular type. The variation is progressive since *T1a* gives a paler type *T1a₂*, and *T1b* gives a darker type; and it is reversible to a certain extent since *T1a* gives the parent type *T1*. The frequency with which *T1b* types are recovered from *T1* is 0.4 % and from *T1a*, 0.3 % indicating that the change to *T1b* occurs at the same rate in *T1* and *T1a*. The reversion from *T1a* to *T1* probably takes place at the same rate as the original change (*T1* to *T1a*), since *T1* gives 2.2 % of *T1a* types and *T1a* gives 1.7 % of *T1* type. *T1a₂* appears to be more variable than *T1* and *T1a₁* giving 18.9 % of variant colonies. *T1a₂* sectors more frequently than the other types; it is probably, actually, as well as apparently, less stable than *T1* and *T1a*.

The question arises as to whether the changes are to be considered as being mutations or not. In so far as they are spontaneously occurring changes which are transmitted from cell to cell, they fall within the category of mutational changes. Since sexual reproduction has not been observed in this fungus it is not possible to follow the transmission of these changes during sexual reproduction. We cannot determine in this way whether the changes are transmitted by the nucleus. It is difficult however to see how results of such regularity could be obtained if the factors causing them are cytoplasmic. It may be possible to get some evidence regarding the location of these factors by studying diploid strains. 'Gigas' forms of a different strain of N.R.R.L. 1978B have been obtained by camphor treatment. These forms are probably diploid. It is hoped to obtain such 'gigas' forms of 1249 B21 and study variation in them. If the forms are diploid and if the changes which affect sporulating capacity occur in the nucleus, the variation pattern would be different from that of the haploid.

Mutation rate

It is clear that if the variants observed are due to mutations at a particular region (region being used in a general sense to mean either a gene or a piece of chromosome) the changes are of such a high frequency that the region may be considered a 'mutable region'. Such a mutability may be due to faulty reproduction of a particular segment leading to repeated reduplication and loss. If this is so, conditions affecting the rate of nuclear division might possibly affect the mutation rate. It is hoped to test the effect of environmental conditions such as changes of temperature on the rate of mutation in an attempt to obtain some clue as to the fundamental nature of the mutation.

The determination of the mutation rate is a very difficult problem. Delbrück (1945) has discussed the subject in relation to bacteria and much of his discussion is relevant to fungi also. So far as the radial growth of a colony on an agar surface is concerned it is clear that at any one point on the circumference of the colony there is very great competition as to which hyphae shall continue the growth and produce a new sector. When mutant nuclei are present in fewer numbers than the original nuclei, they have less chance of being present in the hyphae which carry on the growth of the colony. Mutants will only succeed in establishing themselves as sectors when they occur with a very high frequency or when they have an appreciably higher growth rate than the original type. So far as the aerial growth is concerned, the conditions have not been clearly worked out. However, it would be seen that if there is any weighting it would be in favour of the type present in greatest numbers, i.e. the original type. Therefore we may consider the percentage of mutant types recovered as a lower limit for the actual mutation rate. The actual mutation rate is *probably* not lower than the percentage of mutations recovered and is possibly higher.

Bunting (1940 *a, b*) describes the occurrence of colour variation in *Serratia marcescens* which is similar in certain respects to the variation described in

this paper. She found progressive variation in the sense that the dark red type gave a bright pink variant which in its turn gave a pale pink variant. She also found reversion since the bright pink and pale pink types both gave dark red types. This corresponds to the fact that T_{1a} and T_{1a_2} both give T_1 types. However, in the case of *Serratia* the dark red types gave 2 % of bright pink colonies whereas the bright pink colonies gave 42 % of dark red colonies.

Skovsted (1943) has described what he calls 'successive mutation' in the yeast-like species, *Nadsonia Richteri*. Mutants were picked out as sectors reaching the edge in giant colonies. A number of single-celled cultures of the same original type each gave the same two types of mutants. Each of these types produced three new types. Two of these types were tested and each gave four new types. Five of these eight types were tested and gave altogether twenty-three new types. Thus although only two new types were obtained from the original type, many new types were derived from the mutants. Skovsted did not observe any examples of reverse mutation. However, the competition for survival in a colonial form is such that sectors can only be formed by mutants which occur very frequently and have a growth rate not less than the normal or by mutants which have a higher growth rate on the normal. The shape of the sectors illustrated by Skovsted shows that many of the mutants have a growth rate greater than that of the normal. In such conditions reverse mutations would not be normally detected even if they occurred because they could not compete with the new type. It might be possible, however, to detect them by altering the medium so as to favour the original type at the expense of the mutant. They could also be detected, if frequent, by plating out a large number of single cell colonies. Until such experiments have been made one cannot be sure that reverse mutations do not occur in *Nadsonia*.

Mycelial types

Mycelial types have been described for *Penicillium notatum* by Hansen and Snyder (1944). They relate the occurrence of such types to the 'dual phenomenon' which they have described in a large number of fungi imperfecti. Single spore (multinucleate) isolations of a number of fungi gave three types: *M*, mycelial, *C*, conidial and *MC*, intermediate. *M* types gave only *M* types, *C* types gave only *C* types, whereas *MC* types gave all three types when single spore isolations were made. *MC* types could be synthesized by putting *M* and *C* types together. *MC* types were thus found to be heterokaryons containing *M* and *C* nuclei. Later it was found that *M* types could arise from *C* types and that this often happens with great regularity whereas *M* types are stable, never having been observed to revert to *C* types although subjected to different cultural conditions. Earlier, Mohendra and Mitra (1930) described the occurrence of segregation of black colony (conidial) and white colony (mycelial) types during spore formation in *Sphaeropsis malorum*. This appears to be an example of the 'dual phenomenon' of Hansen (1938) and of Hansen and Snyder (1948) and here also the mycelial type did not revert to the conidial type. Mohendra and Mitra relate the supplantation of the black colony type by the white

colony type during mass conidial transfers to the slower germination and reduced viability of the black colony types.

Mycelial types have been observed mostly in fungi imperfecti and therefore it has not been possible to test the segregation of such types during sexual reproduction. However, Hansen and Snyder (1943) were able to cross *M* and *C* strains of *Hypomyces Solani* f. *Curcurbitae*. It was found that the mycelial-conidial character segregated in a 1 : 1 ratio and was independent of the incompatibility factors. It was also found that whereas the conidial type was hermaphrodite the mycelial type did not produce perithecia and could only function as a male. Hansen and Snyder therefore consider the change from the conidial to the mycelial habit to be a true mutation from a hermaphrodite to a male condition. In *Bombardia lunata*, Zickler (1937) found the *lanata* factor, which appears to be a factor for mycelial growth, to be absolutely linked to a female 'sex realisor' and to be independent of the incompatibility factors. Robbins and Ma (1945) describe physiological experiments on *Trichophyton mentagrophytes* in which they used the conidial wild type and a series of 'pleomorphic' types obtained from old cultures of the conidial type. The situation in *Trichophyton* resembles that in *Penicillium* in that a number of such types are found and in the non-reversion of these types to the conidial habit.

The mode of origin of these mycelial types is an interesting problem. The orthodox genetical hypothesis would be that they were mutations to a type or types which could grow on the surface of old cultures and which would tend to be selected in transferring from old cultures. However, such mycelial types would not be expected to become established in the wild because of the absence of a satisfactory propagating mechanism such as that provided by the conidia on the wild type. In *Hypomyces Solani* f. *Cucurbitae* and *Bombardia lunata*, where the presence of a sexual stage permits the testing of the mutation theory, the mycelial type behaved as a single gene change, but in *Penicillium* and *Trichophyton* no such direct test is yet possible. If the mycelial types are mutational in origin, the question arises as to whether the different mycelial types within one species are due to different mutations or whether there is one mutation for mycelial types and the differences are due to modifying factors or cytoplasmic effects. The presence of the mutable series affecting sporulation capacity suggests that mycelial types may occur as an end result of this series. A frequently occurring type of mutation such as this would account for the frequent appearance of mycelial patches on old cultures. If this is so and all mycelial types are due to one type of change then such types when inoculated together would not give the wild type. This was reported by Pontecorvo and Gemmell (1944) in *Penicillium* and has been confirmed by me (1946). Also $T_{11}a$ and $T_{11}a_2$ when grown together do not give patches of T_{11} type, which is in accordance with the view that they are in some sort of allelic series. These results however may be due to the less highly sporulating habit being dominant over the conidial habit as suggested by Pontecorvo and Gemmell (1944).

It is hoped that further investigations will disclose whether there is a connexion between the 'mutable region' and the production of mycelial types or not.

Penicillin production

In these experiments as in those of Raper and Alexander (1945) there was a negative correlation between sporulation capacity and penicillin production in the conidial types. This, however, may be due to some physiological or mechanical effect of sporulation on penicillin production rather than to a direct effect of the gene affecting sporulation on penicillin production. Mycelial types were found to be poor yielders.

A series of variants with increased production of yellow pigment showed a decreased production of penicillin. This accords with previous reports.

SUMMARY

The standard strain of 1249 B21 constantly throws paler and darker variants. The paler variants throw the darker variants, revert to the parental type and throw still paler variants. The latter are unstable giving all the darker types.

The colour is related to, and may be conditioned by, sporulating capacity.

The greater part of the variation exhibited by young cultures is due to changes in this particular 'mutable region'.

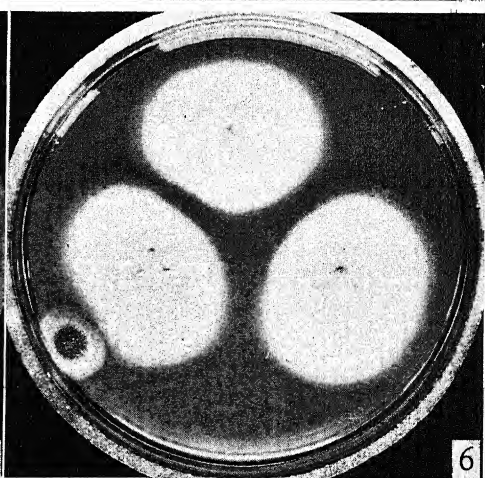
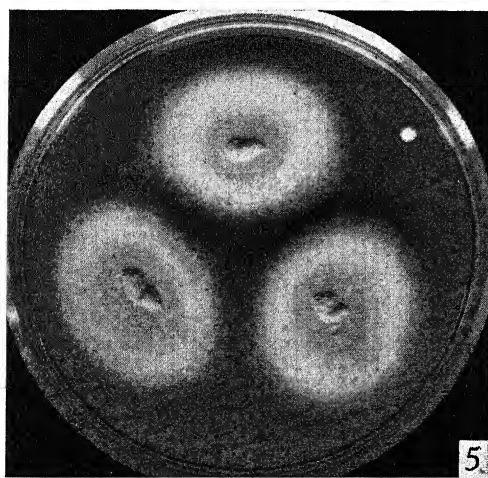
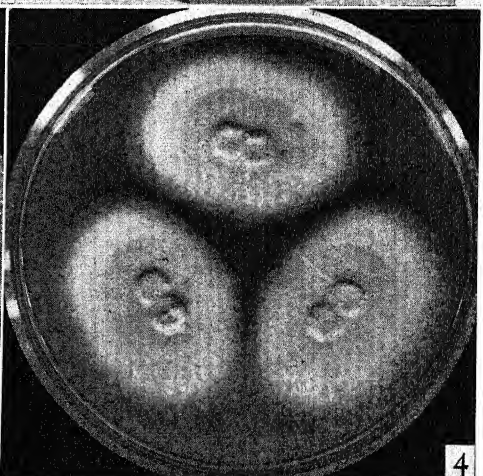
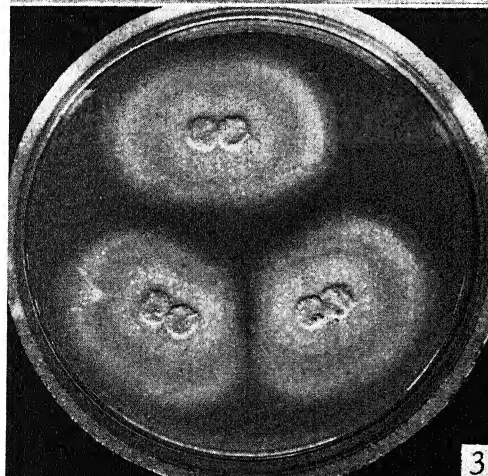
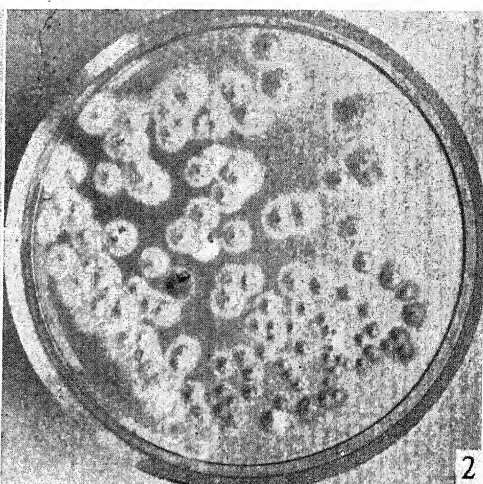
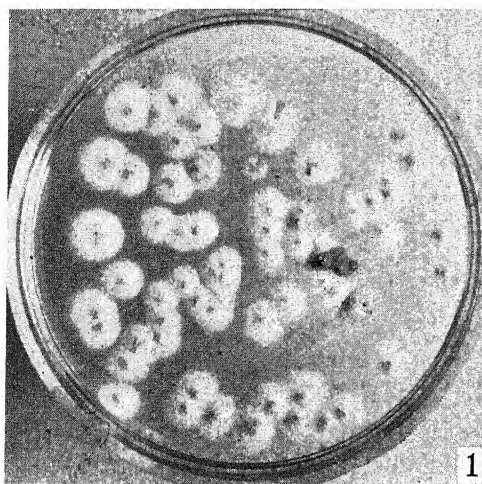
Patches of mycelial growth frequently occur on old single spore cultures as well as on old mass inoculation cultures. Mycelial types which do not normally revert to the conidial type can be isolated from these patches.

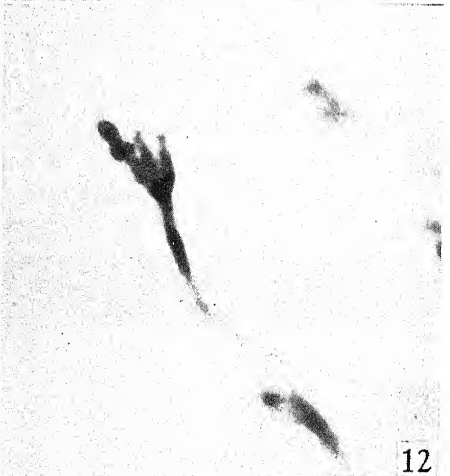
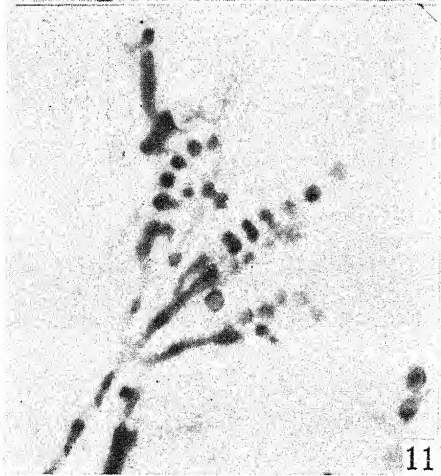
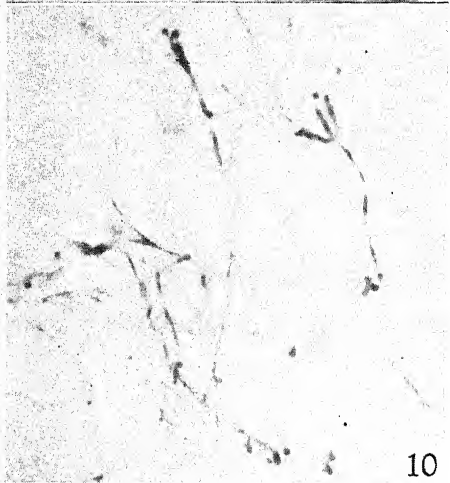
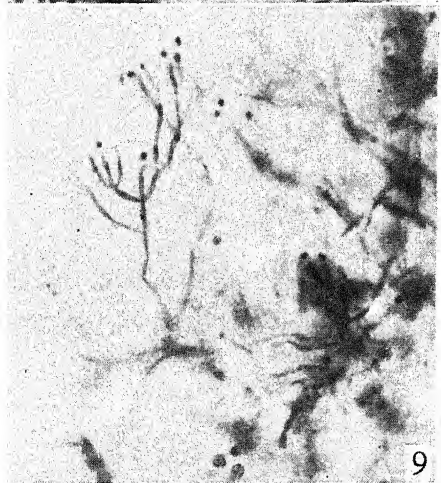
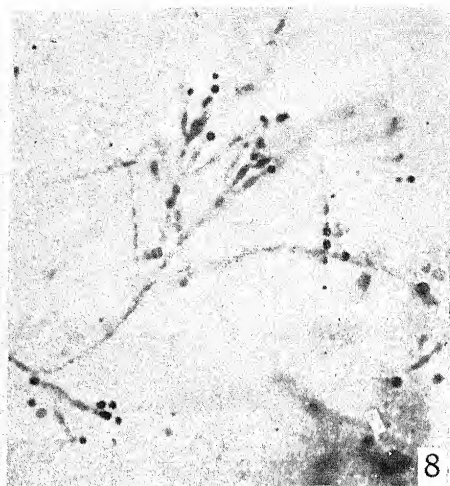
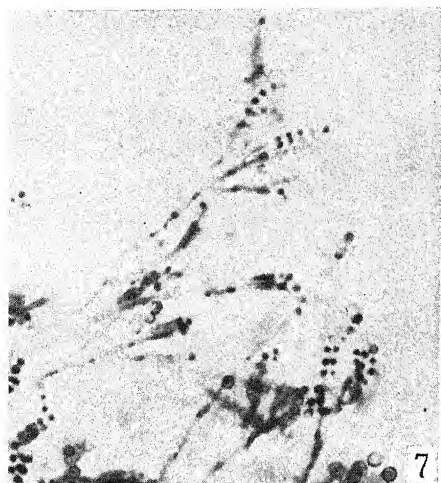
It is suggested that there may be a relationship between the 'mutable region' and the production of mycelial types but no direct link between the two phenomena has yet been observed.

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EXPLANATION OF PLATES

PLATE VI

All cultures photographed on malt agar

- Fig. 1. Seven-day colonies from a plating of T1a type. Three variants of T1 type and two of T1b type are visible.
- Fig. 2. Seven-day colonies from a plating of T1 type. One variant of T1b type and eight of T1a type are visible (dark colonies on right due to shadow).
- Fig. 3. Inoculation of one T1b strain at top of Petri dish, inoculation of a second T1b strain of independent origin at left of Petri dish and side-by-side inoculations of two strains at the right of the Petri dish. One strain shows a mutant sector.
- Fig. 4. Similar inoculations of two strains of T1 type separately and combined (combination at the right).
- Fig. 5. Similar inoculations of two strains of T1a type.
- Fig. 6. Similar inoculations of two strains of T1a2 type.
- Figs. 3-6. Eight-day cultures.

PLATE VII

Photomicrographs, figs. 7-10 $\times 500$; figs. 11, 12 $\times 1000$

- Fig. 7. T1b from nine-day culture.
- Fig. 8. T1 from nine-day culture.
- Fig. 9. T1a from nine-day culture.
- Fig. 10. T1a2 from twenty-six-day culture.
- Fig. 11. Single penicillus of T1b.
- Fig. 12. Single penicillus of T1a2.

Slides fixed formol alcohol, stained chlorazol black and mounted gum chloral.

(Accepted for publication 2 November 1946)

ON MYZOCYTIUM MEGASTOMUM DE WILDEMAN

By HILDA M. CANTER, B.Sc.

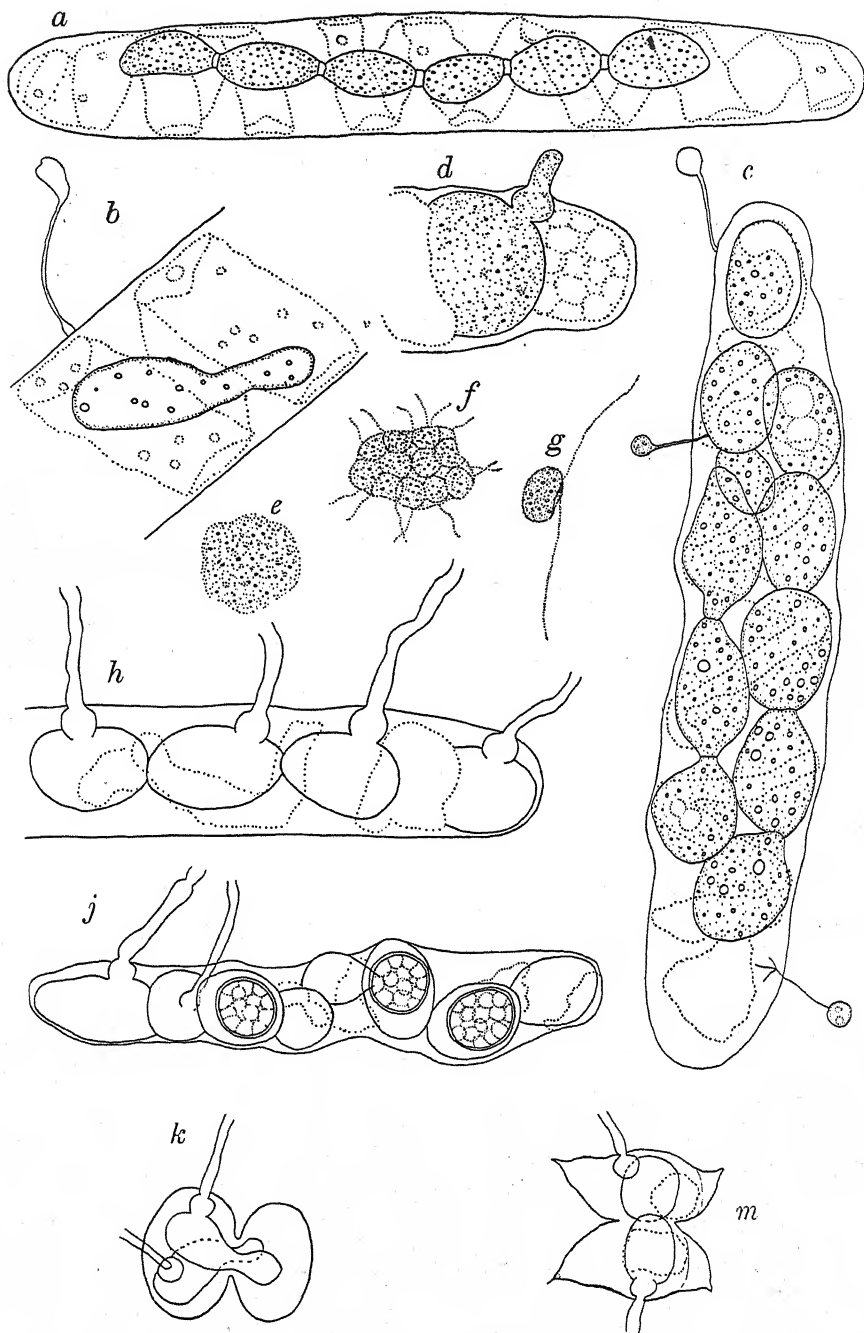
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(With Plate VIII and 3 Text-figures)

Since *Myzocytiium megastomum* was originally described by De Wildeman (1893) a number of references to it have appeared in the literature (Scherffel, 1914; Skvortzow, 1925; Cejp, 1935; Berdan, 1938; Karling, 1942), but because of the lack of knowledge of the zoospores, its exact systematic position has remained in doubt. According to Sparrow (1943), this species has not been recorded from Britain. However, Prof. C. T. Ingold (personal communication) in 1944 found this organism attacking *Euastrum ansatum*, *Closterium costatum*, *C. rostratum* and *Pleurotaenium Ehrenbergii* from Woodhouse Eaves near Leicester (Text-fig. 2 a-f), but again the zoospores were not observed. In July 1946 I found *Myzocytiium megastomum* parasitizing *Spirotaenia condensata* Bréb., in Little Green Tarn, Claife Heights, near Hawkeshead, Lancashire, and the biflagellate zoospores were observed, showing that this fungus really belongs to the genus *Myzocytiium*. A single specimen of what is believed to be this fungus was found in *Closterium* from the Clay Pond, Wray Castle, Windermere, in September 1946. It differs from the material from Green Tarn and Woodhouse Eaves in the more globular zoosporangia ($21-26\mu$ in diameter) and in the larger zoospores (9μ in diameter). Mature sporangia and stages in the formation of the biflagellate zoospores are shown in Text-fig. 3, and Pl. VIII, figs. 3, 4. Young thalli and resting spores were not observed. An account of *Myzocytiium megastomum* on *Spirotaenia condensata* follows.

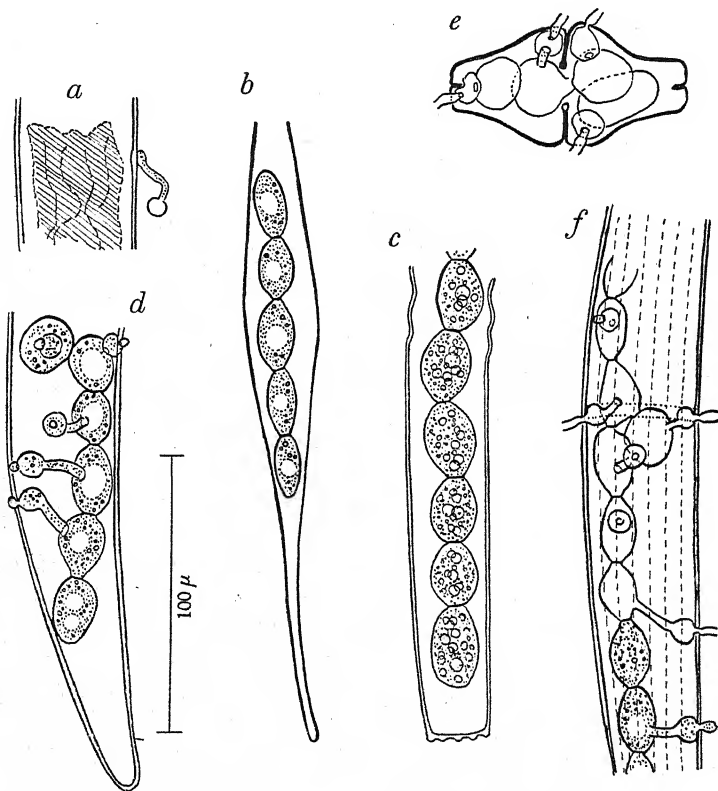
The young endobiotic thallus is relatively short and not subdivided by constrictions. At this early stage of development the empty encysted zoospore and its germ tube apparently connected with the thallus, could usually still be seen outside the host cell (Text-fig. 1 b). The thallus elongates and becomes constricted into portions each of which later becomes a single sporangium. The young sporangia are often separated from one another by a plug of refractive material (Text-fig. 1 a) which disappears as the sporangial wall thickens. Such plugs were not observed by Prof. Ingold in the material from Woodhouse Eaves (Text-fig. 2 b, c). The number of sporangia from any one infection into which the thallus is transformed varies from about one to eight, but more than one thallus may be found in a single host cell. The mature sporangia are ovoid, ellipsoidal or spherical ($32-19.8\mu$ long \times $15-13.2\mu$ diam.), with hyaline cytoplasm containing many scattered highly refractive globules (Text-fig. 1 c).

By the time the sporangia are mature the host chloroplast is reduced to a brown residue, although it still exhibits a somewhat spiral form. At last, from each sporangium a discharge tube is formed which is expanded



Text-fig. 1. *Myzocyttium megastomum*. *a*, chain of young sporangia separated by refractive plugs, $\times 500$. *b*, very young thallus; zoospore case, and infection tube visible outside the host cell, $\times 975$. *c*, eleven mature sporangia, the host chloroplast now very shrivelled; germinated zoospores of a chytridiaceous organism also present, $\times 750$. *d*, early stage in the development of the discharge tube from the sporangium, $\times 975$. *e*, discharged undifferentiated zoospore mass, $\times 750$. *f*, zoospore mass showing differentiation of zoospores and fringe of flagella, $\times 750$. *g*, a zoospore, $\times 975$. *h*, empty sporangia with typical swelling of the discharge tube within the host cell, $\times 750$. *j*, a *Spirotaenia* cell containing two dehiscent sporangia, and three resting spores; the males are distinguished by the absence of a discharge tube, $\times 500$. *k*, *Cosmarium contractum* with possible dwarf thalli, $\times 500$. *m*, the same in *Staurostrum lunatum*, $\times 500$.

immediately within the host wall. This is the characteristic feature of this species. According to the place of germination of the sporangia relative to the host cell wall, the endobiotic swelling may either be almost sessile on the sporangium (Text-fig. 1 *d, h*) or at some distance from it (Text-fig. 2 *d, f*). The discharge tube, except for the intramatrix swelling ($4-6\mu$ in diameter), is equally cylindrical throughout its length (2.6μ wide) and may extend up to 30μ in length outside the host wall (Text-fig. 1 *h*). The



Text-fig. 2. *Myzocytyum megastomum*. *a*, empty zoospore case with germ tube on *Closterium costatum*; *b*, chain of sporangia each with a conspicuous vacuole in *Closterium rostratum*; *c*, chain of sporangia in *Pleurotaenium Ehrenbergii*; *d*, germinating sporangia, each discharge tube swollen immediately inside the algal wall, in *Closterium costatum*; *e*, four empty sporangia in *Euastrum ansatum*; *f*, chain of sporangia in various stages of development in *Closterium costatum*. In most of the figures the disintegrating host contents are omitted. (Drawn by C. T. Ingold.)

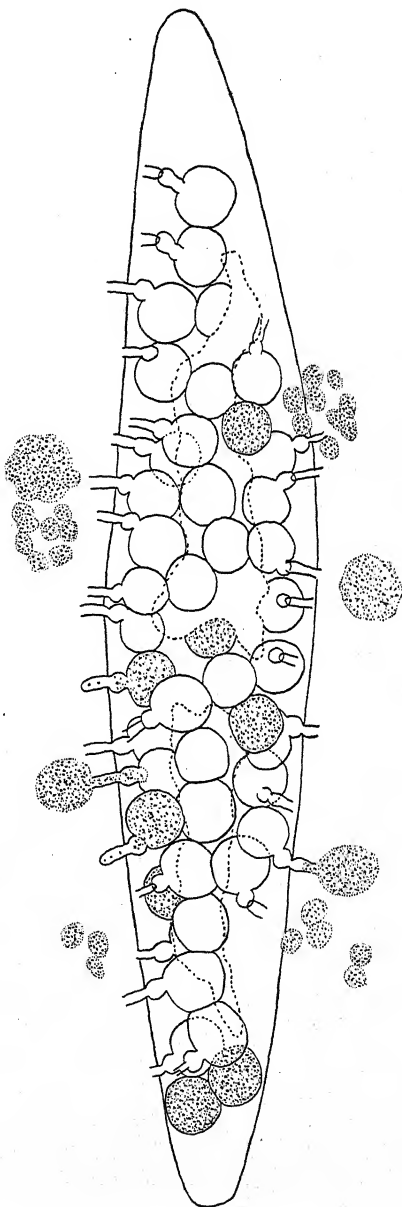
extramatrix prolongation of the discharge tube in the material from Woodhouse Eaves appears to be relatively short (Text-fig. 2 *e, f*). On deliquescence of the apex of the discharge tube, the contents of the sporangium emerge to form a spherical granular mass 17μ in diameter with numerous small refractive globules (Text-fig. 1 *e*). This mass undergoes slight amoeboid movements and, some ten minutes later, the zoospores

gradually become differentiated, and the flagella appear as a fringe of short, actively waving structures around its periphery (Text-fig. 1f). The zoospores remain entangled by their flagella for some time, but finally break free and swim away individually. Each zoospore mass becomes resolved into ten to fourteen somewhat bean-shaped zoospores ($4.5\text{--}5\mu$ long \times $5.6\text{--}7\mu$ diam.) with granular protoplasm containing several small refractive globules. There are two flagella of about equal length inserted laterally in a slight depression. One flagellum is directed backwards and the other forwards when swimming (Text-fig. 1g).

Resting spores are formed abundantly together with the sporangia, and agree with those described by De Wildeman (1893). The mature resting spores are spherical, $13\text{--}15\mu$ in diameter, with a smooth thick wall, and oily contents (Text-fig. 1j). No convincing young stages in the development of these resting spores were seen, but it is clear that they are formed by a sexual process. In only one specimen was any definite fertilization tube connecting the male and female gametangia observed (Text-fig. 1j). The male gametangia can always be distinguished from the empty sporangia by the lack of discharge tubes. The resting spores are usually formed at the side of the female gametangium nearest the male. Their germination was not observed.

Young thalli of a chytridiaceous organism were also present on the *Spirotaenia* cells (Text-fig. 1c), but further stages in the life history of this fungus are not yet known.

The following records of *Myzocytyum megastomum* have already been made: from Belgium, Switzerland and Norway (De Wildeman, 1893, 1895, 1896); Hungary (Scherffel, 1914); Manchuria (Skvortzow, 1925); Bohemia (Cejp, 1935); and America



Text-fig. 3. *Myzocytyum megastomum*. Sporangia in various stages of development in *Closterium* sp. $\times 300$.

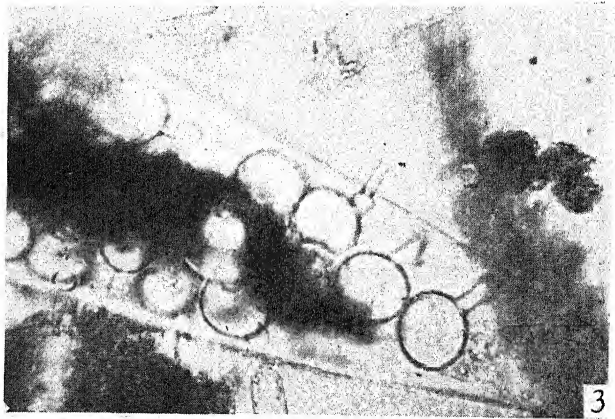
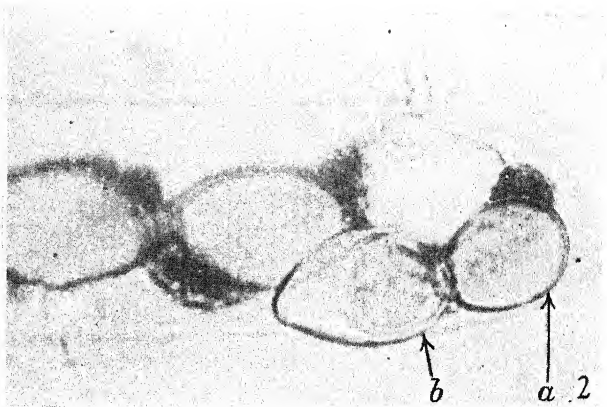
(Berdan, 1938). Karling (1942) rightly lists *Ancylistes miurii* Skvortzow (1925, p. 432, figs. 7-10) as a synonym.

From the many observations on *Myzocyttium megastomum* it would seem that the expansion of the discharge tube within the host wall is a good specific distinction separating *M. megastomum* from the closely allied *M. proliferum* (Schenk). If this is so, then, the *M. proliferum* of Martin (1927; in *Cladophora* sp.), the specimen recorded by Sparrow (1943; in *Closterium costatum*, Farlow Herbarium no. 642), and that of De Wildeman (1895, p. 76, pl. 2, figs. 7-9; in *Euastrum*) should be included in *Myzocyttium megastomum*, a course not followed by Karling (1942). De Wildeman's specimen in *Euastrum* is peculiar in producing only one sporangium instead of a chain of sporangia, and probably represents a reduced form. Similar simplified thalli were seen in the Leicestershire collection (Text-fig. 2e); by myself in August 1946 from the plankton of Lake Windermere, South Basin, in *Cosmarium contractum* (Text-fig. 1k) and *Stauroastrum lunatum* (Text-fig. 1m), and by Petersen under *Myzocyttium irregulare* (1909; 402, fig. 16d; 1910; 538). Karling (1942), in agreement with Fischer (1892), De Wildeman (1896) and Minden (1911), has suggested that *Bicrium transversum* and *Bicrium naso* (Sorokin, 1883) may also represent dwarf thalli of *Myzocyttium*, and since *B. naso* has an endobiotic swelling on the discharge tube this species would be referable to *M. megastomum*. The superficial similarity of these simplified forms of *M. megastomum*, in the smaller desmids, with *Olpidium immersum* Sorokin cannot be overlooked, and since the zoospores of *O. immersum* have not been observed this may be found to belong to the genus *Myzocyttium*. However, only when the zoospores, and resting spores of dwarf thalli of *Myzocyttium*, *Bicrium naso* and *Olpidium immersum* have been observed, and inoculation experiments on various desmids been carried out, will the true nature of these fungi be established.

My thanks are due to the Director of The Freshwater Biological Association, Wray Castle, Windermere, for the use of a laboratory in which this work was done, and especially to Prof. C. T. Ingold for helpful criticism, and permission to publish his figures of *Myzocyttium megastomum*.

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EXPLANATION OF PLATE VIII

Myzocyttium megastomum De Wildeman

- Fig. 1. Part of a *Spirotaenia* cell containing sporangia. The disorganized spiral chloroplast of the host is clearly visible. $\times 780$.
- Fig. 2. Three empty zoosporangia and a resting spore in *Spirotaenia*: (a) the male, (b) the female, containing a thick-walled resting spore. $\times 1230$.
- Figs. 3, 4. Parts of a *Closterium* cell from the Clay Pond, Wray Castle, with zoosporangia in various stages of development. The swelling of the discharge tube immediately within the host wall is well marked. $\times 450$.

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BRITISH FUNGI

By W. C. MOORE, *Plant Pathology Laboratory, Harpenden*

1. *Peronospora Dipsaci* Tul., in *C.R. Acad. Sci., Paris*, xxxviii, 1103 (1854); Gäumann, *Monogr. Gattung Peronospora*, 238 (1923).

On leaves of *Dipsacus sylvestris* L., Dundry, Somerset, May 1941 (L. Ogilvie) and Bricketwood, Herts, October 1946 (A. Smith).

2. *Sphaerotheca fuliginea* (Schlecht.) Salm., in *Mem. Torrey bot. Cl.* xxix (1902).

On cultivated *Doronicum*, Wye, Kent, July 1938 (W. M. Ware); Luton, Bedfordshire, October 1939. Probably widely distributed.

In the material from Luton the perithecia were $81-96\mu$ (average 87μ) in diameter, the asci $62-72 \times 51-55\mu$ (average $67 \times 52\mu$) with 6-8 ascospores.

3. *Oidium* sp.

On *Antirrhinum majus* L., Bucks, March 1928 (W. Buddin); Devon, Newton Abbot, April 1928 (A. Beaumont); Cambridge, February 1934 (F. T. Brooks); and later at Cardiff (J. Rees); Shrewsbury (N. C. Preston) and Harpenden.

Usually slight, under glass, and probably not uncommon. At Harpenden seen also after planting out, and at Shrewsbury severe on bedded out plants. At Harpenden forming a sparse white web or dusty covering on under-surfaces of leaves, and occasionally on upper surface. Conidia hyaline, almost rectangular, with slightly rounded ends or occasionally barrel-shaped, $24-45 \times 12-17\mu$ (average of forty spores $30 \times 14.5\mu$).

4. *Oidium* sp.

On soft young tips of gorse shoots (*Ulex* sp.) in the Malvern Hills, July 1931 (G. H. Pethybridge).

The only previous record of a powdery mildew on *Ulex* appears to be one in Ireland in 1906. Adams (1906) recorded *Cicinnobolus Ulicis* n.sp. as 'parasitic on one of the Erysiphaceae on stems and leaves of *Ulex europaeus*, which it covers with a felt of hyphae bearing pycnidia (Figs. 2, 3 and 4), July. On Great Sugar Loaf, Co. Wicklow.' A specimen of the Irish material from the Crypt. Coll. Dublin, when examined in 1931, showed very little mildew and that only in the *Oidium* stage.

5. *Gibberella moricola* (de Not.) Sacc., *Michelia*, i, 347 (1879); Sacc. *Syll. Fung.* ii, 553.

On dead fig twigs (*Ficus Carica* L.), Dorset, January 1946 (W. Buddin).

Perithecia present in large numbers, mostly immature though a number of ripe ones found, free on substratum or partly immersed, scattered or aggregated into small tightly packed groups, black (blue in transmitted light), $210-450\mu$ (mostly $240-300\mu$) in diameter, and mixed here and

there with a few immature buff-coloured ones. Asci cylindrical or club-shaped, 60–90 μ long, containing eight monostichous or subdistichous ascospores, sometimes fewer. Ascospores straight or occasionally slightly curved, variable in size and shape, usually egg-shaped to spindle-shaped, but sometimes broader at one end than the other, 1–5, mostly 3-septate, generally with a slight constriction at the septum, 16–25 \times 6–9 μ (average of twenty spores 20 \times 7 μ), those with two septa broad in relation to their length. A few orange-pink sporodochia of a species of *Fusarium* present among the perithecia, with immature sickle-shaped spores, 20–31 \times 3–4 μ , having acute ends and no discernible septa.

Wollenweber and Reinking (1935) distinguished *Gibberella baccata* (Wallr.) Sacc. var. *moricola* (de Not.) Wollenw. (= *G. moricola*) from *G. baccata* (Wallr.) Sacc. by its somewhat smaller spores. Miss E. M. Wakefield has, however, drawn my attention to the fact that in *Syll. Fung.* II, 553, Saccardo gives the larger spores (24–30 \times 6–7 μ) for *moricola* and smaller spores (16 \times 8 μ) for *baccata*. But when Miss Wakefield examined two of Saccardo's specimens in Herb. Kewensis, which had been distributed in Myc. Ven. nos. 652 and 653 as *Botryosphaeria pulicaris* f. *Mori albae* on *Morus alba*, and *B. pulicaris* f. *baccata* on *Robinia pseudacacia*, respectively, she found that the relative spore sizes were the reverse of those given in the *Sylloge*. The form on *Morus* had spores which were straight and rather cylindric, narrowing only comparatively slightly towards the ends; and measuring 16–22 \times 5–6 μ . The *baccata* form had larger, more fusiform spores (25–30 \times 6–7 μ), most of which were slightly curved. From my observations, the material on *Ficus* from Dorset corresponded more closely to the form on *Morus* than to the *baccata* form in Saccardo's specimens, and it is therefore identified with *Gibberella moricola*.

The record of *G. moricola* on *Morus* in Hants, listed by Bisby and Mason (1940), is an error of transcription: the imperfect stage only of the fungus (*Fusarium lateritium* Nees) was reported in the paper cited.

6. *Leptosphaeria heterospora* (de Not.) Niessl, *Beitr.* 23 (1872); Sacc. *Syll. Fung.* II, 67.

On rhizomes and roots of *Iris germanica* near Woking, Surrey, March 1930; on var. Ann Page in St James's Park, London, October 1930; on *I. pumila formosa* in Kent 1932; and on *I. germanica* near Aylesbury, Buckinghamshire in May 1946.

The fungus is found on unthrifty and yellowing plants and is probably a weak parasite. After making healthy but rather weak growth for several weeks in spring, the outer foliage becomes brown and withered, and the younger leaves turn yellow and begin to die back from the tips. On lifting affected plants, the rhizomes appear firm and show no decay, but most of the roots are withered and dead, or are reduced to discoloured, hollow tubes. The black perithecia can be found in appreciable numbers partially embedded in the surface of the rhizomes, especially on the underside, and there are usually a few on the roots. The *Leptosphaeria* was associated with a species of *Phoma* (with spores 4–6 \times 1.5–2 μ) in the material from Aylesbury, and with *Septoria* sp. in that from Kent.

7. *Ophiobolus rubellus* (Pers. ex Fr.) Sacc. *Michelia*, II, 324 (1882); Bisby and Mason in *Trans. Brit. myc. Soc.* xxiv, 194 (1940); syn. *O. porphyrogonus* (Tode) Sacc. *Syll. Fung.* II, 338.

On roots of unpulled and badly weathered flax (*Linum usitatissimum* L.), Pembrokeshire (Hayscastle and Dinas Cross), September 1945 (D. L. G. Davies).

8. *Phyllosticta camelliaeicola* Brun. var. *meranensis* Bubák, in *Öst. bot. Z.* 80 (1905); Sacc. *Syll. Fung.* xviii, 224 (1906).

On living leaves of *Camellia*, St Albans, Herts, May 1939. Spots rounded, brown or paling, with a well-defined darker, narrow margin, raised especially on the underside, and believed to be caused primarily by insects. Pycnidia on both sides of spots, scattered, small, immersed. The spores in this specimen agreed with those of Bubák's variety ($3-5 \times 1-1.5 \mu$).

Phyllosticta camelliaeicola Brun. *Misc. Mycol.* p. 13; Sacc. *Syll. Fung.* x, 101 (1892), with spores $5-6 \times 2-3 \mu$, is regarded by Grove, *Coelomycetes*, I, 10 (1935), to be the same as *P. Camelliae* Westd. in Kickx, *Flor. Crypt.* I, 416, for which there are no spore measurements. *P. Camelliae* was recorded from Cound, Salop, in January 1939 (N. C. Preston), but no specimen is available.

9. *Phomopsis viticola* Sacc., in *Ann. Mycol., Berl.*, xiii, 118 (1915); Grove, *Coelomycetes*, I, 237 (1935).

On base of shoot of a vine branch, Dunraven Castle, Glamorgan, May 1931 (J. Rees).

10. *Sphaeronema pruinosum* Peck in Rep. St. Mus.

On branch of a six-year-old apple tree at Otley (Yorks), April 1928; the branch was infested with Mussel Scale and was rather extensively cankered.

Pycnidia almost superficial, more or less conical or columnar, containing macro- and microspores. The larger spores measured $16-27 \times 9-12 \mu$ (average of twenty, $23 \times 10 \mu$) and were mixed with large numbers of hyaline, straight or slightly curved, unicellular, filiform spores, $6-13 \times 1-2 \mu$ (average length of twenty, 9.3μ). The characters of the fungus agreed closely with those of *Glutinium macrosporum* Zeller, described by Zeller (1927) as the cause of a canker of apple and pear trees in Oregon. Examination of some of the Oregon material, however, which Dr Zeller sent at my request, revealed certain minor differences between the two fungi, which were not regarded as sufficient to justify specific distinction. According to Zeller (1927) the pycnidia of *G. macrosporum* produced in culture had smaller spores than those ($15-28 \times 8-10.5 \mu$) found in nature. The spores were hyaline and showed only false septation on germination. The fungus induced a slow rot of apple fruits, but no pycnidia developed on the fruit. The spores of the English fungus in culture were up to 30μ long. Moreover, some of the spores became pale brown, and on germination they sometimes became truly 1-3-septate. Pycnidia similar to those in culture developed on apple fruits slowly rotted by the fungus.

Miss E. M. Wakefield, who also examined the two fungi, pointed out that *G. macrosporum* Zeller did not differ from *Sphaeronema pruinosum* Peck, the conidial stage of *Pezicula pruinosa* Farlow, which was originally described on *Amelanchier*. She examined material in Herb. Kewensis on *Amelanchier* from Farlow's Herbarium, and also a specimen collected by J. B. Ellis, said to be on elder, which Peck had identified as *Sphaeronema pruinosum*, and they did not differ from one another or from *Glutinium macrosporum*. Later, Zeller (1935), having examined Peck's type, accepted this view, though he did not regard the fungus as a good species of *Sphaeronema*.

11. *Ascochyta bohémica* Kab. & Bub., in *Hedwigia*, XLIV (1905); Sacc. *Syll. Fung.* XXII, 1024 (1913).

On leaves of *Campanula medium* L., Harpenden, September 1941 (J. M. Gooby). Previously found in Britain on *C. betulaefolia* and *C. Ranieri* at Maidenhead (*Trans. Brit. myc. Soc.* xxiv, 60).

On *C. medium* the spots were round or sub-angular, 2–10 mm. in diameter, epiphyllous at first, later visible on both sides of leaves, brown, dry, with a broad purple margin 2 mm. wide. Pycnidia few, with spores mainly unicellular and biguttulate, mostly $12 \times 6 \mu$, occasionally 1-septate, constricted at the septum and then with several guttules. Perhaps an immature *Stagonospora*.

12. *Ascochyta Cinerariae* Tassi, in *Boll. Orto. bot. Siena*, 31 (1899); Sacc. *Syll. Fung.* xvi, 930.

On decayed stem bases of cineraria plants in pots, at Carrington and Manchester, Lancashire, December 1934 (E. Holmes Smith); and at Woburn Sands, February 1940 (W. Buddin).

At Woburn Sands associated with a basal stem rot causing heavy loss among plants growing in fresh loam in new pots. Pycnidia numerous, aggregated, erumpent, globose or lens-shaped, very variable in size, $180\text{--}250 \mu$ ($\text{--}300 \mu$) in longer axis (average of ten, 200μ), pale brown, thin-walled parenchymatous, cells somewhat thickened and darker around a well-defined ostiole $25\text{--}35 \mu$ in diameter. Spores hyaline or slightly coloured, egg shaped, $6\text{--}10 \times 3\text{--}5 \mu$, mostly 1-septate when mature. In Lancashire associated with basal stem rot in 40 % of young pot plants. This fungus agrees closely with *Ascochyta Cinerariae* Tassi, which has been described as the cause of a leaf spot of cinerarias in Germany (Wasewitz, 1936) and Italy. The pycnidia are lighter than those of *A. (Diplodina) Lycopersici*, from which the fungus is otherwise not dissimilar. *Diplodina (Ascochyta) fibricola* (Sacc.), recorded on rotting stems of *Cineraria maritima* in France (Rab. *Krypt. Fl.* I, vi, 682 (1901)), appears to be different.

It is uncertain whether *Ascochyta Cinerariae* is parasitic on the stem bases of cinerarias, producing a disease similar to but distinct from Foot Rot caused by *Phytophthora cryptogea* Pethybr. & Laff., or whether it merely develops secondarily on the stem bases of plants primarily affected with Foot Rot. No *Phytophthora* was found in the Woburn material.

13. *Ascochyta dahliaicola* (Brun.) Petr., in *Ann. Mycol. Berl.*, xxv, 201 (1927); syn. *Phyllosticta dahliaicola* Brun., *Champ. Saint.* 429 (1887); Sacc. *Syll. Fung.* x, 129 (1892); Grove, *Coelomycetes*, I, 14 (1935).

On *Dahlia variabilis* Desf., Wokingham, Berks, September 1937 (W. Buddin); var. *Clara Carder*, Harpenden, Herts, October 1941 (W. Buck).

14. *Ascochyta Impatiens* Bres., in *Hedwigia*, 326 (1900); Sacc. *Syll. Fung.* xvi, 927.

On living leaves of *Impatiens balsamina* L., Newton Abbot, Devon, October 1942 (A. Beaumont).

Pycnidia scattered or aggregated, globose or flattened, immersed, thin-walled, pale brown and translucent, 120–150 μ diam., opening with a pore about 15 μ wide. Spores issuing in dense clouds, straight cylindrical with rounded ends, 6–11 \times 2–4 μ , mostly 9 \times 3 μ , ultimately 1-septate, not constricted at the septum.

A. Weissiana Allesch., Rab. *Krypt. Fl.* I, vi, 647 (1899); Sacc. *Syll. Fung.* xvi, 927, on *Impatiens balsamina* in Saxony, may be the same but is described as having black-brown pycnidia, and spores measuring 10–16 \times 3–4.5 μ .

15. *Botryosporium longibrachiatum* (Oudem.) Maire, in *Ann. Mycol. Berl.*, I, 340 (1903); Mason in *Annotated Account of Fungi received at the Imperial Bureau of Mycology*, List II (Fascicle 1), 27.

On tomato stems, Rustington, Sussex, September 1943 (W. A. Millard).

16. *Cercospora Primulae* Allesch., in *Ber. Bayr. Bot. Ges.* II, 18 (1892); *Hedwigia*, xxiv, 286 (1895); Sacc. *Syll. Fung.* xi, 607.

On living leaves of *Primula Wanda*, Staffs, July 1928; and on hybrids of *P. juliae*, Bridge Sellers, Hereford, August 1931, Gamons, Hereford, March 1933 (L. Ogilvie), and Bartley, Southampton, May 1936 (*Trans. Brit. myc. Soc.* xxv, 208).

17. *Fusicladium Lini* Sorauer, in *Z. PflKrankh.* v, 103 (1895); De Wild. & Dur. *Prodr. Fl. Belg.* II, 336.

Forming a black coating on wilted cotyledons and lower leaves of *Linum usitatissimum* L., Egmore, Norfolk (R. E. Taylor) and in Wiltshire (L. Ogilvie), June 1942.

Conidiophores simple, usually fasciculate, septate, pale brown, more or less rigid, straight or somewhat bent, ultimately up to over 200 μ long, and 3–6 μ broad. Spores borne singly at tips and at times apparently pleurogenous by the continued growth of the conidiophore, mostly straight, or sausage-shaped, pale coloured, with a clearly defined wall about 1 μ thick, minutely apiculate, 12–37 \times 5–9 μ (average of twenty-five spores 24 \times 7 μ), continuous or 1-septate, sub-catenulate. Sorauer did not give a full description of his fungus and gave the spores as only 8 \times 4 μ , with some 14–16 μ long.

Sorauer regarded *Fusicladium Lini* as a parasite and the cause of wilting and discoloration of the upper portions of flax seedlings in Belgium,

van Poeteren (1929) found what he thought was the same species, or possibly only *Cladosporium herbarum*, on yellow and dwarfed flax seedlings in Holland. In England the fungus was associated at both localities with yellowing and slow wilting of young seedlings and of plants just beginning to flower.

I am very much indebted to Miss E. M. Wakefield for continued help and interest and to all those collaborators who have sent me material.

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AN IMPROVED TECHNIQUE FOR THE STUDY OF LIVING MYCELIUM

By J. A. MACDONALD

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Sass (1929) described the agar-film technique by which fungus mycelium was grown on microscope slides carrying a thin film of a special semi-solid, agar-containing, nutrient medium. Noble (1937) and I (1937) employed a modified technique in which the slide carrying the film was placed face downwards in a groove cut in a brass box-frame, made to measure to fit the slide, and the frame was then put in a Petri dish containing damp blotting paper. For examination under the microscope the lid of the Petri dish was removed. Light passed to the microscope lenses through the bottom of the Petri dish, the film and the slide. The lid could be replaced after examination and the fungus allowed to continue growth or, as soon as observations of interest were made on nuclear behaviour, the position on the slide was marked and noted by mechanical stage readings, the film was fixed, stained and examined and the observations made before fixation were interpreted in terms of the structures now rendered visible. The worst disadvantages of this method are the variable thickness of the Petri-dish glass which affects the light, the thickness of the slide and the cloudy nature of the medium through which the fungus hyphae have to be viewed. Only a very limited number of short lengths of hyphae can be brought into focus using a $\frac{1}{4}$ or $\frac{1}{12}$ in. oil-immersion lens, even when 'extra-thin' microscope slides are used.

The following improved technique is now being used in this Department in studying the hyphae (particularly the clamp connexions) in certain Basidiomycetes. The microscope slide to carry the film is replaced by a large glass coverslip 2×4 in. of the type used to cover fossil preparations, or better still by a 1×3 in. no. 3 or no. 2 cover-slip. The bottom of the box-frame is set on an 'extra-thin' microscope slide. The medium employed for the film is 1.5 % malt in 1.5 % British agar. As before, the films are grown in Petri-dish damp chambers. They are removed for examination resting on the brass box. The microscope slide completes the base of this small damp chamber. Films of this type have been kept growing under a $\frac{1}{16}$ in. oil-immersion lens for hours on end—sometimes overnight—before fixation or return to their Petri dishes. The small chamber is comparatively easy to manipulate and hyphae may be traced backwards from their tips up to six fields of view under either a $\frac{1}{12}$ or $\frac{1}{16}$ in. lens. By this means the formation of clamp connexions has been watched repeatedly in fungi such as *Coniophora puteana* and *Marasmius androsaceus*. In the latter species the time from the inception of the bulge on the parent hypha to the beginning of the outgrowth of a branch from the completed,

fused clamp connexion is 50–60 minutes. The formation of the clamp itself takes about 20 minutes, with the greatest regularity.

Marasmius androsaceus forms its clamp connexions in full daylight—during ordinary working hours!—and the technique is simple enough for advanced students to be trusted to use the equipment and watch the process for themselves.

An account of results observed is in preparation for publication.

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STUDIES ON BRITISH CHYTRIDS

II. SOME NEW MONOCENTRIC CHYTRIDS

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(With Plates IX and X and 8 Text-figures)

Few workers have been attracted to a detailed study of the aquatic Chytridiales in Great Britain (Cook, 1932; Sparrow, 1936; Ingold, 1940, 1941 and 1944), and thus the number of records for this country remains relatively small. Intensive work carried out by me on these organisms during the past two years shows that they are to be found in almost any aquatic habitat provided that a suitable substratum for growth is present. Since the Chytridiales are as yet a relatively unexplored group, the discovery of new species is not uncommon, and several are described in this paper.

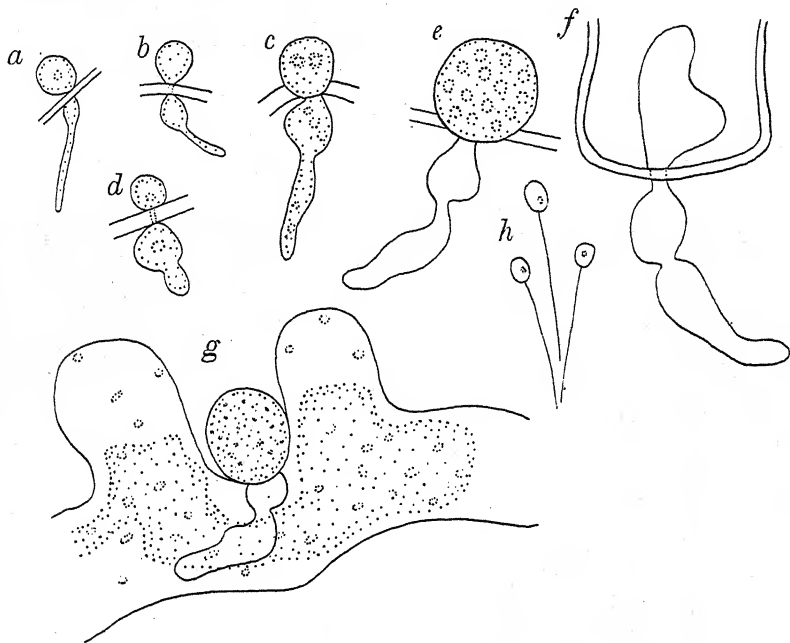
I. *Phlyctidium apophysatum* n.sp.

This chytrid was found on *Mougeotia* from the Clay Pond, Wray Castle, Windermere, in August 1945. Outgrowths from the cells are of common occurrence in *Mougeotia*, and sporangia of the fungus were often located between two such processes. The fungus is parasitic and brings about a dissociation of the host chloroplast into numerous granules.

The thallus is monocentric, and consists of an extramatrical sporangium, an intramatrical apophysis and unbranched tubular rhizoid. Young stages (Text-fig. 1*a-d*) indicate that the apophysis is formed early, as a swelling of the germ-tube, the distal part of which develops into the tubular rhizoid. The apophysis is spherical to subspherical, and never exceeds the diameter of the sporangium. The sporangium is spherical to oval, 9–17 μ in diameter and usually produces a hundred or more zoospores, which are liberated upon deliquescence of the apex of the sporangium. The zoospores (Text-fig. 1*h*) are oval, 1.4 \times 2.4 μ , with a minute refractive globule, and a single posterior flagellum about 13 μ long; their movement is somewhat jerky. The apophysis and sporangium tend to collapse after dehiscence. Several smaller sporangia, 7–12 μ in diameter, were observed (Text-fig. 1*e*). They contained a few regularly arranged, relatively large oil globules, but whether they actually liberate zoospores with a conspicuous globule is unknown, as dehiscence was never seen. Resting spores were not observed.

This fungus shows very clearly the dubious nature of the characteristics which have been used to separate the genera *Phlyctidium* and *Phlyctochytrium*. It resembles a species of *Phlyctidium* in the nature of its unbranched rhizoid, and a species of *Phlyctochytrium* by the possession of an apophysis.

Sparrow (1933, p. 518, Pl. 49, fig. 12) described an incompletely known fungus on *Cladophora*, probably a *Phlyctidium*, with a rhizoidal system very similar to that of the present species; *P. spinulosum* (Sparrow, 1933, p. 516, Text-figs. 1, 2) also has a slightly inflated tubular rhizoid, and it is decided to include the fungus here described in the genus *Phlyctidium* as a new species, *P. apophysatum*, taking its name from the constant, and well-developed intramatrix apophysis.



Text-fig. 1. *Phlyctidium apophysatum* n.sp. a-d, young thalli. e, sporangium possibly containing zoospores with a large oil globule. f, dehiscent sporangium. g, large sporangium situated between two processes of the *Mougeotia*. h, zoospores. a-f, h, $\times 1400$; g, $\times 660$.

Phlyctidium apophysatum n.sp.

Thallus monocentric, consisting of an extramatrix sporangium $9-17\mu$ in diameter, an intramatrix apophysis, either spherical 5μ in diameter, or subspherical $6.7 \times 10\mu$, never exceeding diameter of the sporangium, continuous with a tubular rhizoid ($24 \times 7\mu$) to ($12 \times 3.3\mu$). Zoospores oval $1.4 \times 2.4\mu$ with a minute colourless globule, and posterior flagellum 13μ long, discharged on deliquescence of the apex of the sporangium. Resting spores not observed.

Parasitic on *Mougeotia* sp. Clay Pond, Wray Castle, Windermere, England, August 1945.

Phlyctidium apophysatum sp.nov.

Thallus monocentricus, sporangiis extramatrixlibus, apophysibus et rhizoideis intramatrixlibus. Sporangia $9-17\mu$ diam. Apophysis sphaerica 5μ diam. aut subsphaerica $6.7-10\mu$, nunquam sporangio latior.

Rhizoideum tubulare $12 \times 3.3 \mu$ ad $24 \times 7 \mu$. Zoosporae ovales, $1.4-2.4 \mu$, globulo hyalino minuto, postice uniflagellatae, flagello 13μ longo, ex apice sporangii dissoluto emergentes. Sporae perdurantes non visae.

Hab. in *Mougeotia* sp. parasiticum, Clay Pond, Wray Castle, Windermere, Anglia, August 1945.

II. A SPECIES OF *RHIZOPHIDIUM*

Scherffel (1926) described a chytrid parasitic on the sporelings of *Oedogonium* which he referred tentatively to *Rhizophidium globosum*. In February 1946 a very similar organism was found parasitizing the same host, in Clissold Park Lake, London.

From one to fourteen individuals of the parasite may occur on a single sporeling, and when only one is present a characteristic curvature is induced in the host cell, the chloroplast of which is converted into a mass of brown granules (Text-fig. 2c and Pl. IX, fig. 4).

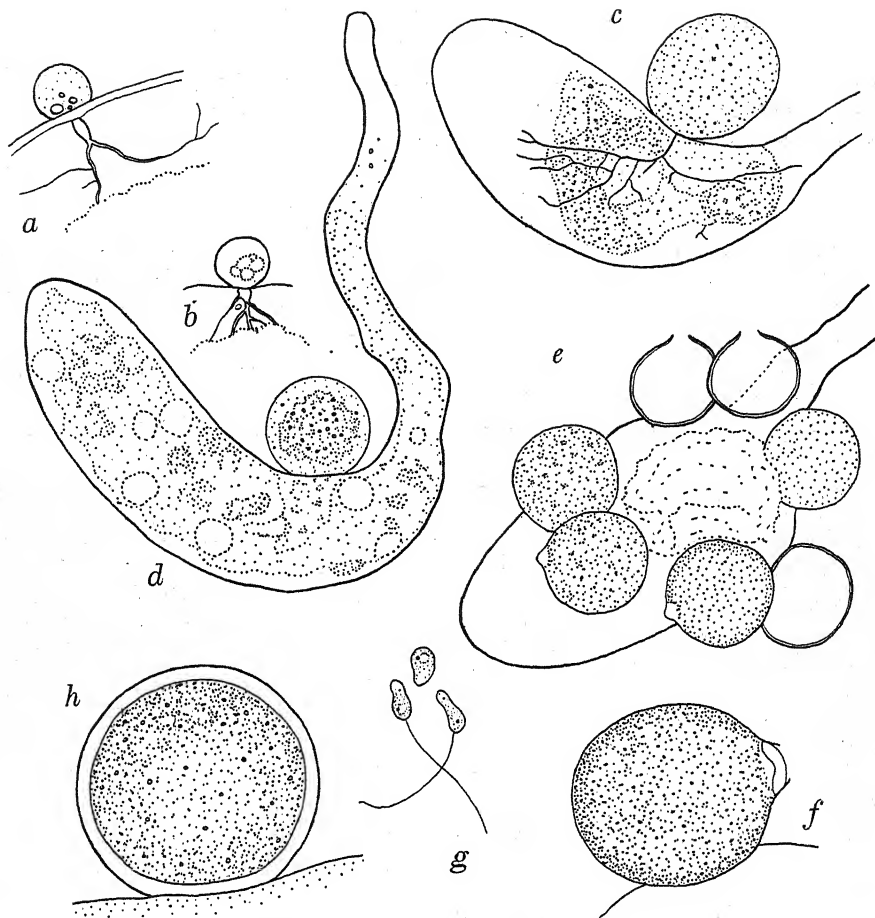
The rhizoidal system is often difficult to observe owing to the dense chloroplast of the host, but where visible it consists of a main axis, rarely slightly swollen immediately beneath the host wall (Text-fig. 2a, b), which branches to give a meagre rhizoidal system. The spherical sporangia vary in size from 7.5 to 34.3μ in diameter, and where many occur on a single host cell they are relatively small.

As the sporangium matures a single lateral dehiscence papilla becomes visible, and it appears to be filled with a plug of highly refractive material. The part of the sporangium wall forming the papilla deliquesces, but whether the plug also deliquesces or is extruded as a solid mass is unknown, as the actual moment of dehiscence was never observed. Hundreds of posteriorly uniflagellate zoospores 4μ long, 2μ diameter, are produced. They are of unusual structure for a chytrid since they have no conspicuous oil globule, but they contain one or two minute, highly refractive granules, often situated laterally near the posterior end (Text-fig. 2g).

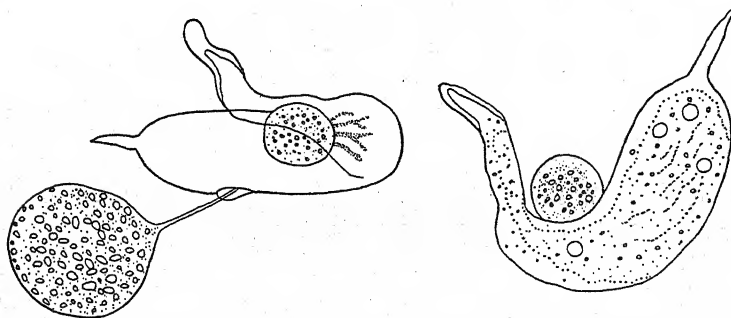
Spherical, asexually formed resting spores $21.4-35 \mu$ in diameter were seen, which appeared to produce little effect on the host chloroplast (Text-fig. 2h and Pl. IX, fig. 6). They are similar to the zoosporangia, but the wall is up to 2μ thick; their contents are at first granular, but later become oily. Neither the rhizoids nor germination of these resting spores was seen; one empty specimen showed a single lateral dehiscence pore.

The chytrid here described agrees in all essentials, except one with Scherffel's organism. In the latter the rhizoidal system is stated to consist of a few fairly thick but not long, forked rhizoids, arising from the base of the sporangium (Text-fig. 3), whereas in the London material there is a single main axis. In my opinion this is not a significant enough difference to warrant a separation of the two forms.

Although the chytrid here described is very similar to *R. globosum*, according to Sparrow's (1943) definition it cannot find its true place in this species owing to the smooth-walled resting spore. Great difficulties are presented in dealing with the globose species of *Rhizophidium*. The records are numerous, but only rarely is a complete description given. Observations on the structure and method of formation of the resting spores is of



Text-fig. 2. *Rhizophidium* sp. *a*, *b*, very young sporangia; intramatrix rhizoid is slightly swollen immediately within the host wall. *c*, sporangium with well-developed rhizoidal system. *d*, immature sporangium rhizoids not visible; characteristic curvature of the host present, but contents little disorganized. *e*, mature and dehiscent sporangia. *f*, mature sporangium with lateral plug of highly refractive material. *g*, zoospores. *h*, smooth walled resting spore. *b*, *e*, *h*, *f*, $\times 975$; *a*, *g*, $\times 1333$; *c*, $\times 700$; *d*, $\times 700$.



Text-fig. 3. *Rhizophidium globosum* (after Scherffel, 1926).

utmost importance, and when investigations have been carried out on the specificity and morphological variations of these organisms, a thorough revision of the genus will be necessary.

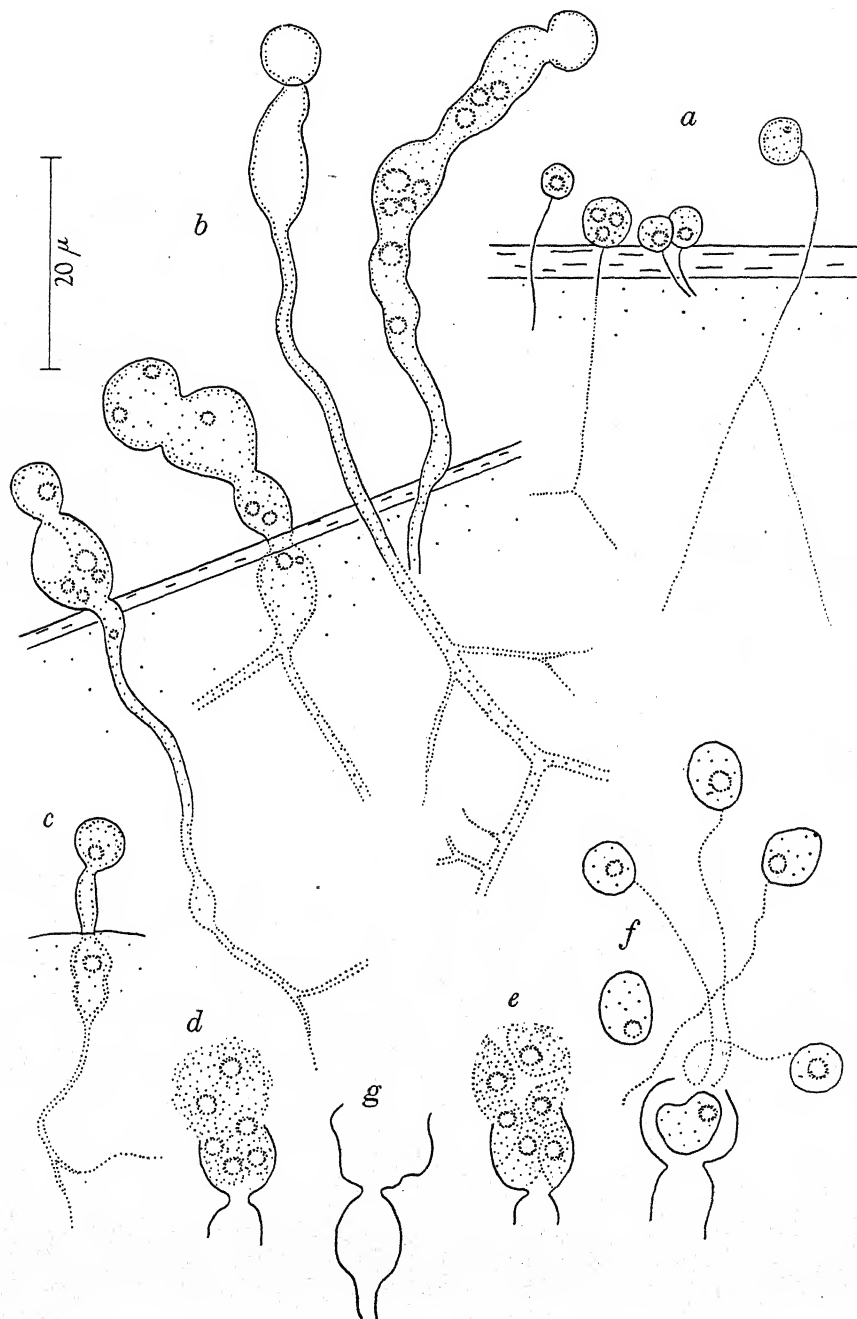
III. *Rhizidium variabile* n.sp.

This fungus was found growing as a saprophyte on *Spirogyra* in May 1945 and 1946, from a pond in Chelsea Physic Garden, London. It appeared after the *Spirogyra* had been kept in the laboratory for some weeks, by which time the algal cells were almost unrecognizable.

The thallus is monocentric, consisting of an extramatrical, usually unbranched system of diverse form and size, and an intramatrical ultimately branched rhizoidal system. The extramatrical part is composed of the body of the encysted zoospore, more or less swollen, continuous with a single stout rhizoid, which may exhibit one or several swellings throughout its length. The zoospore on germination produces a germ tube which branches distally, the swellings developing later. The diversity of the thallus structure is illustrated in Text-fig. 4*b* and Pl. X, figs. 4–6. The exact point where the thallus enters the host cell is often difficult to determine, because of the disorganization of the cell walls. In the material found in 1945 (Text-fig. 4*c*) the intramatrical system of the chytrid was rarely swollen, whereas in the collection made a year later many such specimens were seen (Text-fig. 5*c, e*) which simulated species of the genus *Phlyctochytrium*. During the development of the vegetative part of the thallus the encysted zoospore remains small, later there accumulates in it the protoplasmic contents of the whole thallus, and it enlarges to form a spherical or subspherical sporangium, 6–13 μ in diameter, which contains from one to twelve relatively large zoospores. These exude in a motionless mass on deliquescence of the apex of the sporangium. At first they are amoeboid, but soon round off and swim away. The zoospores are 4.4–5 μ in diameter with an oil globule 1–2 μ in diameter and a single posterior flagellum 26 μ long. The sporangium wall collapses after dehiscence. Resting spores were not observed.

In general structure this species most nearly resembles *Rhizidium mycophilum* Braun, previously recorded from England by Sparrow (1936), growing on exuviae of Chironomidae. However, the series of subsporangial swellings is not a feature of *R. mycophilum*, and the sporangia and number of zoospores produced are much smaller. Further, the zoospore mass does not exhibit the changes in shape that were recorded for Sparrow's material of *R. mycophilum*. Karling (1944) recognizes *R. mycophilum* Braun as two species, *R. mycophilum* Braun and *R. Nowakowskii* Karling (= *R. mycophilum* Nowak), based on differences in habitat, in the structure of the zoospores, and in the resting sporangia. As neither Sparrow (1936) nor I have observed resting spores the exact affinity of the present species cannot be determined.

It is suggested that the present fungus shall be described as a new species, until experiments have been carried out on the morphological variations which occur in single-spore cultures on different hosts in *R. variabile* or its



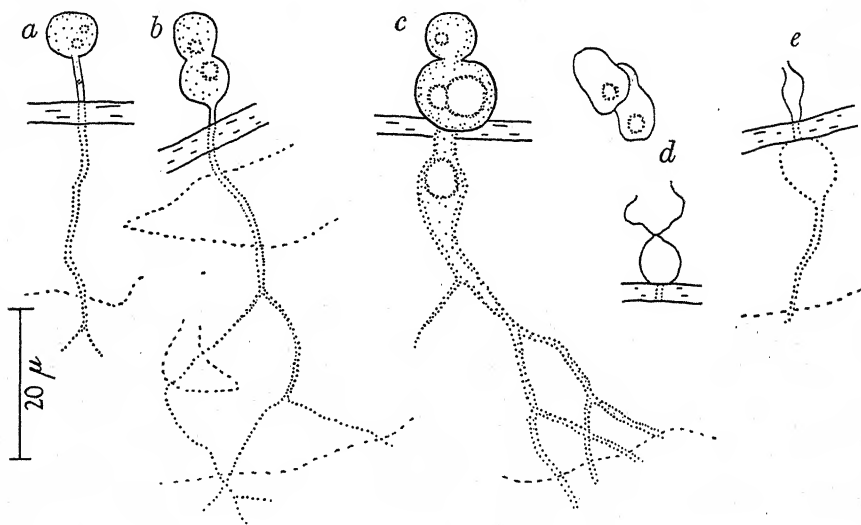
Text-fig. 4. *Rhizidium variable* n.sp. a, germinating zoospores on *Spirogyra* sp. b, variations in thallus structure. c, thallus with endobiotic swelling. d-g, stages in dehiscence of sporangia. (All from Chelsea Physic Garden, 1945.)

near allies, after which it may be necessary to revise the position of this species.

***Rhizidium variable* n.sp.**

Thallus monocentric, extramatrix part consisting of a sporangium $6-13\mu$ in diameter (developed from the encysted zoospore), and a single stout rhizoid, which may have one or more swellings. Intramatrix part sometimes swollen, tapering to a branched rhizoidal system. Sporangium sometimes swollen, tapering to a branched rhizoidal system. Sporangium containing 1-20 zoospores which emerge, surrounded by a vesicle, on deliquescence of the sporangial apex. Zoospores spherical $4.4-5\mu$ in diameter, with a single oil globule $1-2\mu$ in diameter, and a posterior flagellum 26μ long. Sporangium wall collapsing after dehiscence. Resting spores not observed.

On dead *Spirogyra* sp., Chelsea Physic Garden, London, England.



Text-fig. 5. *Rhizidium variable* n.sp. a, b, young thalli with slender branched intramatrix rhizoidal system. c, thallus with extramatrix and intramatrix apophyses. d, empty sporangium, above two zoospores. e, empty collapsed sporangium. (Chelsea Physic Garden, 1946.)

***Rhizidium variable* sp.nov.**

Thallus monocentricus. Pars extramatrix e sporangio et rhizoideo unico dilatationibus singulis vel pluribus praedito consistens. Pars intramatrix interdum inflata, in rhizomycelium ramosum attenuata. Sporangium $6-13\mu$ diametro, zooporas 1-20 includens. Zooporae sphaericae, $4.4-5\mu$ diam., globulo unico hyalino $1-2\mu$, postice uniflagellatae, flagello 26μ longo, vesiculo inclusae emergentes. Membrana sporangii post dehisceniam collabit. Spore perdurantes non visae.

Hab. in *Spirogyra* sp. emortua, Chelsea Physic Garden, London, Anglia.

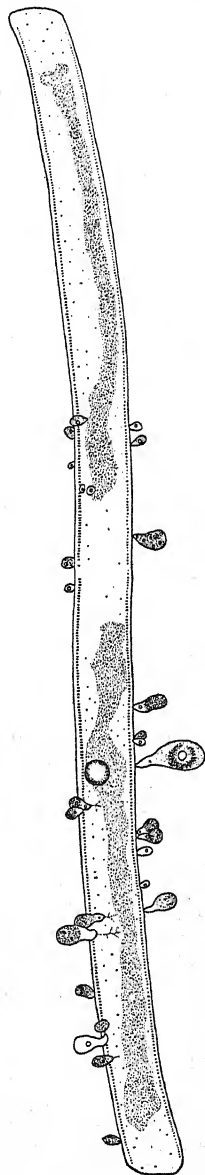
IV. *CHYTRIDIUM VERSATILE* VAR. *ACAULIS*

This chytrid (Text-fig. 7, and Pl. X, fig. 7, 8) was found growing on *Nitzschia sigmoidea* (Ehrenb.) W.Sm., in Bradbourne Park Lake, Sevenoaks, Kent, England, from November 1944 to March 1945. It was also found in a collection from the River Yeo, Sherborne, Dorset, in March 1945.

Although other diatoms were abundant from both localities (e.g. species of *Pinnularia*, *Synechra*, *Navicula*, *Surirella*, *Melosira* and *Gyrosigma*), they were never attacked. It therefore seems probable that the chytrid is specific to *Nitzschia sigmoidea*, as there should have been ample opportunity for infection to occur in the small flocculent masses into which these diatoms were crowded. The fungus is parasitic, but the contents of the infested cells are little affected; the chromatophore retracts somewhat at the point of entry of the rhizoids, but the movement of the host is not impaired. An infected diatom may carry from one to thirty individuals of the parasite (Text-fig. 6).

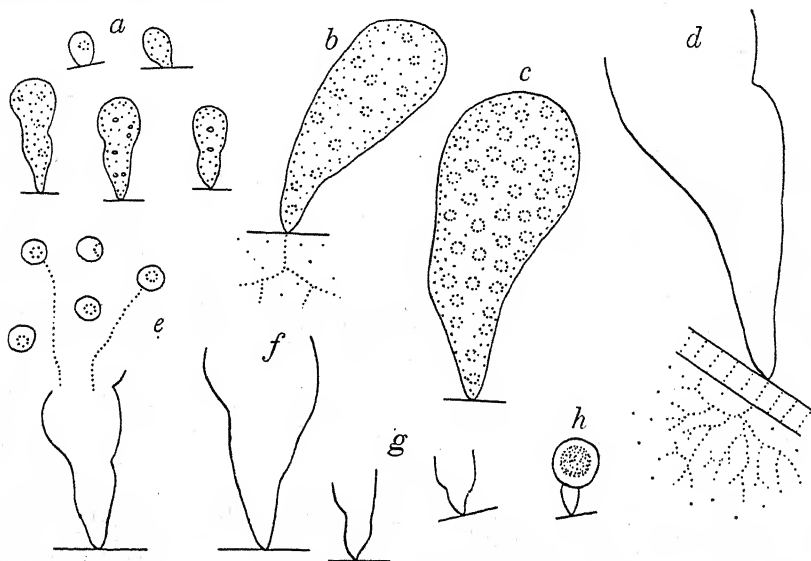
The zoospore encysts on the surface of the diatom and produces a germ tube which usually penetrates a carinal dot. From the base of the germ tube a branched intramatrix rhizoidal system arises (Text-fig. 7*d*). The mature sporangia are obpyriform and taper to a knob-like base sessile on the host. The sporangium wall is smooth, colourless, thin distally, often becoming thickened at the base. The sporangia range from 4 to 25 μ in diameter, and from 15 to 60 μ high; while the smaller sporangia contain a few zoospores, the larger ones may produce eighty or more. The zoospores are spherical, 3–4 μ in diameter, uniguttulate with a single posterior flagellum, and upon the detachment of an apical, rarely somewhat lateral operculum, they escape in a mass from the sporangium but quickly separate, and glide away individually. One probable resting spore was observed (Text-fig. 7*h*), but it is thought unwise to base a description on this specimen alone.

Apart from the absence of a stalk, its larger size and supposed specificity for *Nitzschia sigmoidea*, the fungus agrees well with *Chytridium versatile* Scherffel, already recorded from this



Text-fig. 6. *Chytridium versatile* var. *acaulis*. *Nitzschia sigmoidea* bearing numerous chytrid thalli in various stages of development. $\times 330$.

country by Sparrow (1936). As in *C. versatile* (see Scherffel, 1926) the sporangium bends back as the diatom pushes against debris in its environment, in spite of the fact that this species is sessile. After the obstruction is passed the sporangium snaps back to its original upright position. Scherffel (1926, Plate 9, figs. 19, 20) figures three sporangia apparently without a stalk; however, no mention is made in the text to such sessile forms. Owing to the absence of any major structural differences from *C. versatile* Scherffel it is proposed to erect a new variety, *C. versatile* var. *acaulis*, being characterized by the absence of a stalk.



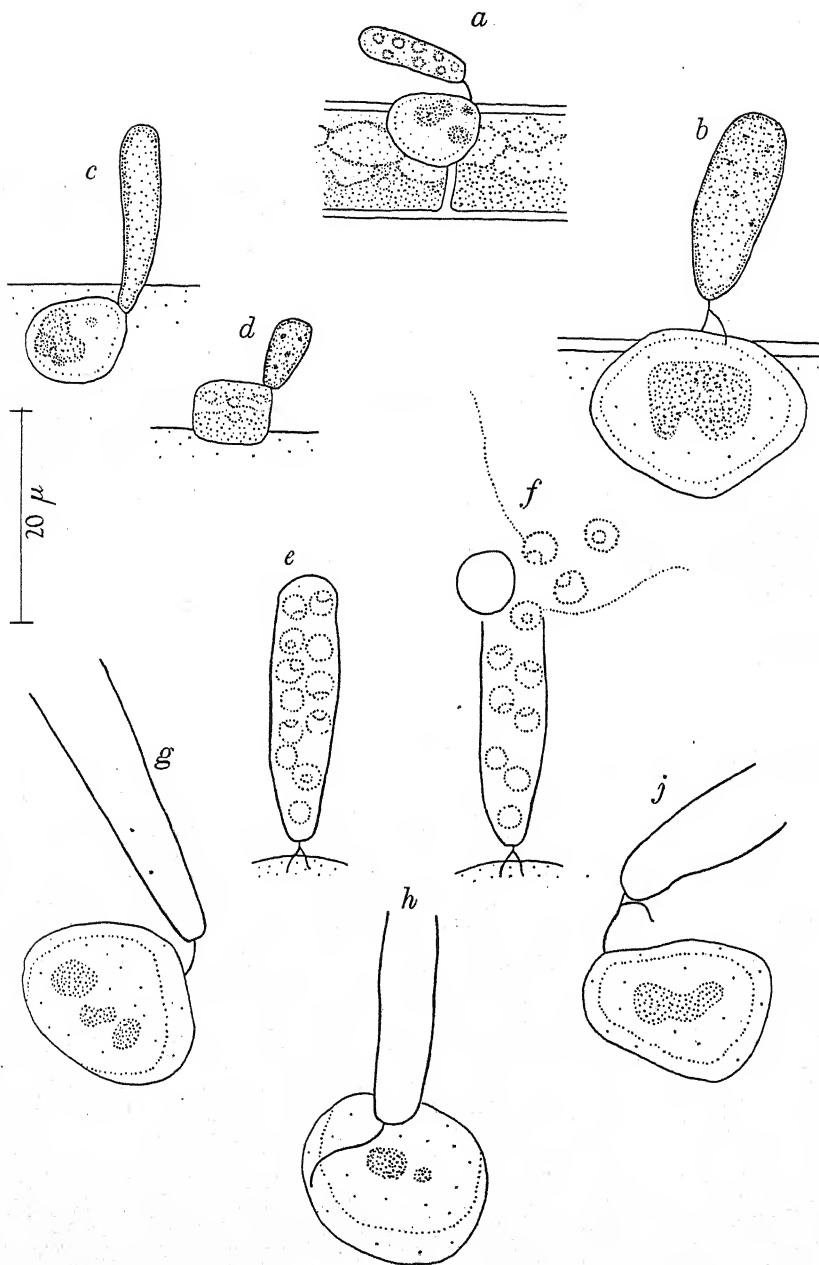
Text-fig. 7. *Chytridium versatile* var. *acaulis*. *a*, young sporangia. *b*, sporangium inclined to long axis of host cell. *c*, mature sporangium. *d*, dehiscing sporangium showing branched rhizoidal system. *e*, zoospores. *f*, *g*, dehiscing large and small sporangia. *h*, resting spore (?). *c*, *d*, $\times 1400$; *a*, *b*, *e*, *f*, *g*, *h*, $\times 660$.

V. *Chytridium cocconeidis* n.sp.

This fungus was found on *Cocconeis pediculus* Ehrenb., itself epiphytic on *Cladophora*, in a small lake in Clissold Park, London, March 1945. Sparrow (1943) records no chytrid on *Cocconeis*, and the organism appears to be an undescribed species.

Judging by the disorganized state of the chromatophores in the affected diatoms, the chytrid is parasitic. It seems to be limited in its host range, since *Rhoicosphenia curvata* (Kg.) Grun., which was also abundant on the *Cladophora*, was not attacked.

The species is monocentric, and the thallus consists of a cylindrical sporangium, and a rhizoidal system. This system consists of an extramatrical part, and presumably also of an intramatrical part, although this was not demonstrated microscopically. The extramatrical part consists sometimes of a straight unbranched portion (Text-fig. 8*a*, *g*, *h*), but at



Text-fig. 8. *Chytridium cocconeidis* n.sp. *a, b*, sporangia with an extramatrical rhizoidal system. *c, d*, mature apparently sessile individuals. *e, f*, mature and dehiscing sporangium. *g, h, j*, empty sporangia.

other times it is forked near the attachment to the host cell (Text-fig. 8*b, e*). Occasionally no extramatrical part was visible, and the sporangium appeared to be sessile on the *Cocconeis* (Text-fig. 8*c, d*). Mature sporangia measure $15\text{--}29\mu$ in length, by $5\text{--}6\mu$ in diameter, and are sometimes inclined at an angle to the main extramatrical rhizoid. The sporangium contains from twelve to thirty zoospores and dehisces by the separation of a convex apical lid $2\text{--}3\mu$ in diameter. Upon detachment of the lid several zoospores escape together, but the remainder emerge singly. The zoospores are spherical, $2\text{--}3\mu$ in diameter, with a conspicuous refractive globule and a single posterior flagellum. Their movement is predominantly hopping, with periods of gliding. The method of infection of the *Cocconeis* by the zoospore was not satisfactorily demonstrated. Resting spores were not observed.

Since this chytrid is operculate, in Sparrow's classification (1943) it belongs to the Chytridiaceae. The only possible genus appears to be *Chytridium*, but this genus contains no species with a branched extramatrical rhizoidal system, although a few species, *C. versatile* Scherffel, *C. curvatum* Sparrow, and *C. Lagenula* Braun pro parte, may have a short slender extramatrical stalk.

Although the inclusion of this species in the genus *Chytridium* may necessitate a slight extension of the concept of the genus, this is nevertheless preferable to the erection of a new genus. The species *C. cocconeidis* is proposed, taking its name from the host upon which it is apparently a specialized parasite.

***Chytridium cocconeidis* n.sp.**

Thallus monocentric, eucarpic, sporangium extramatrical cylindrical $15\text{--}29\mu$ in length, $5\text{--}6\mu$ in diameter, dehiscing by an apical lid, and containing 12–30 zoospores. Zoospores spherical $2\text{--}3\mu$ in diameter, with a colourless globule and single posterior flagellum. Extramatrical rhizoidal system simple or branched $2\text{--}9\mu$ in length, rarely absent. Intramatrical rhizoidal system not observed. Resting spores not observed.

On living cells of *Cocconeis pediculus* from Clissold Park, London, England, March 1945.

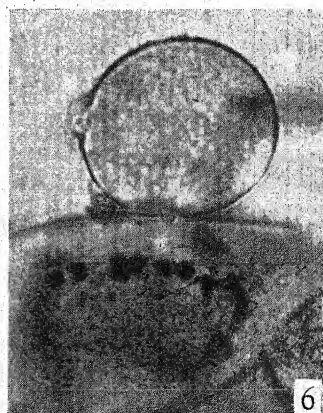
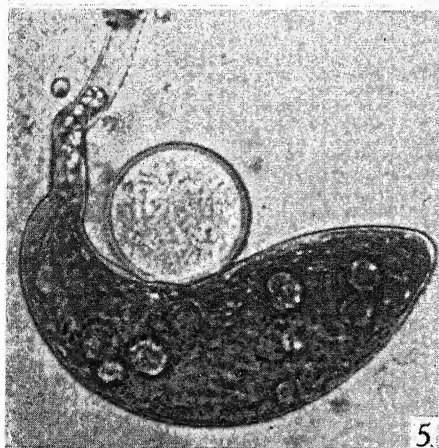
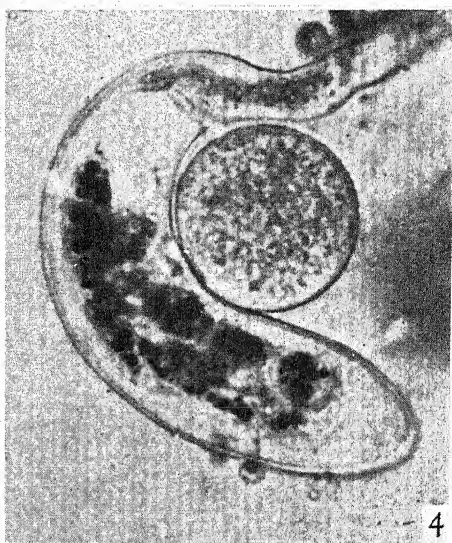
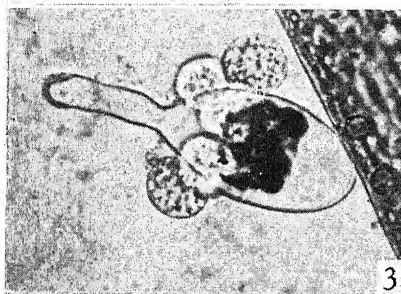
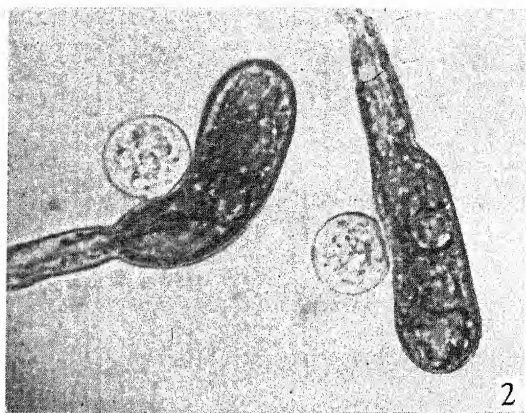
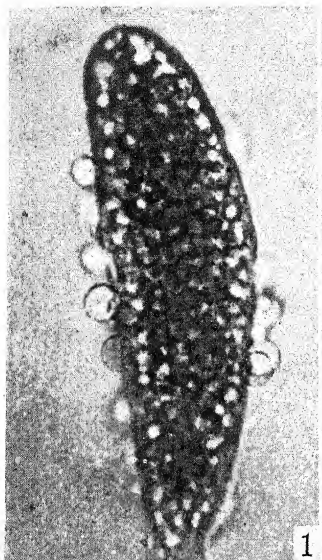
Chytridium cocconeidis sp.nov.

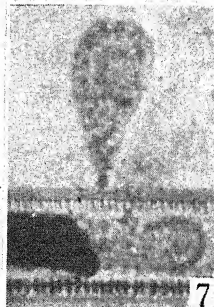
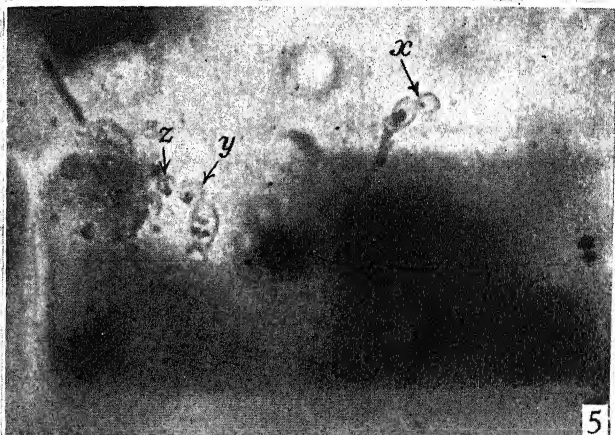
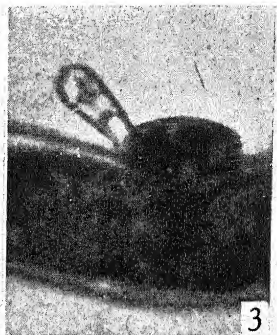
Thallus monocentricus, eucarpicus. Sporangia extramatricalia, cylindrica, $15\text{--}29 \times 5\text{--}6\mu$, operculo apicale dehiscencia, 12–30 zoosporas includentia. Zoosporae sphaericae $2\text{--}3\mu$ diam., globulo hyalino refractivo, postice uniflagellatae. Rhizoidea extramatricalia, simplicia vel ramosa, $2\text{--}9\mu$ longa, raro nulla. Sporae perdurantes non visae.

Hab. in cellulis vivis *Cocconeidis pediculi*, Clissold Park, London, Anglia, Martio 1945.

SUMMARY

Five monocentric chytrids are described growing on algae from Great Britain. Of these, three are new species, namely, *Phlyctidium apophysatum*, *Rhizidium variabile* and *Chytridium cocconeidis*. *Chytridium versatile* var. *acaulis*





represents a new variety, and a species of *Rhizophidium* is identified with *Rhizophidium globosum* Scherffel (1926).

My thanks are due to Miss E. M. Wakefield for the Latin diagnoses and to Prof. C. T. Ingold for the advice he has given throughout the course of this work.

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EXPLANATION OF PLATES

PLATE IX

Rhizophidium sp.

- Fig. 1. Many germinated zoospores on an *Oedogonium* sporeling. $\times 700$.
- Fig. 2. Two sporelings each with a young sporangium; the one on the right already shows a slight curvature. $\times 650$.
- Fig. 3. Sporeling attacked by five sporangia, the chloroplast is very much contracted.
- Fig. 4. Almost mature sporangium. $\times 650$.
- Fig. 5. Sporangium showing lateral region of dehiscence, the outer wall has already deliquesced. $\times 650$.
- Fig. 6. Resting spore with thick wall; the host contents are not disorganized. $\times 650$.

PLATE X

- Fig. 1. *Chytridium cocconeidis*; dehiscent sporangium with zoospores at its apex. $\times 480$.
- Fig. 2. Sporangium with needle-like extramatrical rhizoid. $\times 640$.
- Fig. 3. Cylindrical, apparently sessile sporangium on *Cocconeis pediculus*. $\times 960$.
- Fig. 4. *Rhizidium variable*; young thallus showing encysted zoospore, intramatrical apophysis and rhizoidal system. $\times 560$.
- Fig. 5. Thalli visible at (x, y, z). (x) shows a long extra matrical rhizoid; the cell walls of the *Spirogyra* are just out of focus. $\times 280$.
- Fig. 6. At (a) is a mature sporangium with the oil globules of six zoospores clearly delimited; a young thallus is visible to the right of (a). $\times 736$.
- Fig. 7. *Chytridium versatile* var. *acaulis*, a mature sporangium on *Nitzschia sigmoidea*. $\times 700$.
- Fig. 8. Two dehiscent sporangia. $\times 190$.

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THE USE OF PERFORATED CARDS FOR PRELIMINARY IDENTIFICATION OF FUNGI

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(With 2 Text-figures)

INTRODUCTION

The use of perforated cards for the rapid identification or selection of individuals possessing any particular combination of characteristics is now well known. The method has been successfully used for the identification of timbers from their microscopic structure and other features (Clarke, 1938; Phillips, 1941). An attempt has now been made to construct a perforated card key for the rapid preliminary identification of Hymenomycetes belonging to Polyporaceae and Agaricaceae.

Many would-be students of these groups are discouraged by the initial difficulties which they experience when they attempt to identify specimens by means of the orthodox methods, such as dichotomous keys based on a few characters which may appear to them ill-defined. Nothing encourages students more than to make by themselves a number of successful determinations, and it is with the hope of encouraging them to take an interest in the higher Basidiomycetes that the following suggestions are published.

METHOD

Cards with small marginal perforations are marked out with a list of the most useful diagnostic features. Cards printed with a list of these features may be prepared* or the features may be listed only on a master card and corresponding blank cards prepared for each species to be included in the key. The cards are prepared for use by clipping out the edge of the holes opposite to the number assigned to these particular features that are possessed by the species in question; for instance, if a species is white, soft and possesses a fixed ring on the stem the holes assigned to these characters are clipped out. All the cards of the group that is under consideration are stacked together in a box, *the right way up and facing the same way*, one clipped corner of the card providing a check that this is done. It is then immaterial how they are arranged in the 'pack'.

When using the key the unknown specimen is examined and the most important diagnostic feature is noted. A knitting needle, preferably mounted in a wooden handle, is then run through the hole through the

* The right to produce cards of this kind is covered by patent held by Messrs Copeland Chatterson and Co., London, E.C. 4.

entire pack of cards, which is gently but thoroughly shaken. All the cards describing species which possess this feature fall out; a second well-marked diagnostic feature is then chosen and the needle passed through the corresponding hole in the cards which have fallen out, the process being continued until one card or only a few cards are left. If only a few cards are left it is then usually possible to select the card descriptive of the unknown specimen, since additional notes on characteristic features that are not included in the standard characters assigned to the perforations are written on the cards to assist final diagnosis.

The successful working of any key depends, of course, on the choice of well-defined, constant characters on which to base it.

It is recognized that one of the principal difficulties in satisfactorily describing fungi for purposes of subsequent recognition is the paucity of well-marked characters—shape, size and colour often being so variable as to afford little assistance, whilst other more constant characters, such as texture, are difficult to describe precisely. Such difficulties arise in the construction of any type of diagnostic key, but the perforated card system provides a loophole by which variations can be covered, e.g. if a species is black or white, according to conditions under which it is grown, both of the holes corresponding to these characters are clipped so that the card for this species falls out whether the specimen belongs to the black or the white variety, and its card will be among those chosen for further selection.

ADVANTAGES OF PERFORATED CARD SYSTEM

(1) Any striking characteristic may be chosen to make the first selection, whereas with a dichotomous key the choice of characters and the sequence in which they are made must follow the lines laid down by the author of the key. A few examples will make this clear. In practice one often recognizes a species by its odour or by its change of colour on wounding—such features cannot obviously be made the basis of a formal dichotomous key, but using the perforated cards one can at once select those species having *any* such striking characteristics.

(2) Card key systems permit the inclusion of species with features untypical of the genera to which they belong which have to be treated as exceptions in dichotomous keys: for instance, there are species that possess coloured spores that are normally included in general like *Lactarius* and *Russula* which in some classifications (e.g. Ramsbottom, 1923) are described for the sake of simplicity as possessing white spores.

(3) New species can readily be introduced into the key without affecting the position of those already included.

(4) The number of species included may amount to many hundred without rendering the key unworkable.

While the number of alternative characters that can be included in a card key cannot conveniently exceed 120–130, the blank space in the centre of the card can be used on which to write supplementary information.

The general keys to the Polyporaceae and Agaricaceae illustrated below are intended to serve as guides only to well-marked species or to groups of species. In some genera they will obviously serve only to indicate the groups of species that some taxonomists will regard as subgenera or genera. I wish to emphasize that it would not usually be possible, for instance, to run down a species of *Cortinarius* or *Russula* from a general key to the Agaricaceae of any region, but the key should lead to the group of the particular genus, which can then be studied in detail from a recognized flora. It should be possible for anyone interested in one of these difficult groups to construct for themselves a card key restricted to that particular genus in which the characteristics of the species in the genus are given in greater detail than is possible in the general key. For instance, the diagnostic characters of the species of *Boletus* as described by Pearson (1946) could well be used as the basis on which to construct a perforated card key.

USE OF PERFORATED CARD KEY

It is obviously necessary for the user of a card key to be familiar with the features listed and to have some idea of their relative importance for diagnostic purposes. In using the key for Agaricaceae one would naturally choose first such features as spore-colour, attachment of gills, texture of pileus and stem, and so on. The characters printed on the card are the main basic characters, those assigned to the holes lettered *a, b, c*, etc., are those which amplify or extend the range of the main characters. On the Agaricaceae card, *a-f*, for instance, are additional colours, *g-l* give details of gills, *m-r* of spores and hymenium, while *s-y* describe the upper surface of the pileus in greater detail.

When using the key it is important to realize that some of the features are to be understood as relative to the size of the fungus, for instance, 'flesh thin' or 'flesh thick' is not an absolute quantity in the way that the overall size is—such features should be used only after the more definite characters have been employed.

Fig. 1 shows a sample card from the card key to the Agaricaceae clipped to describe *Amanita muscaria*; for this readily recognized species three features are sufficient to sort out this particular card from the pack, (1) the volva, (2) the fixed ring, (3) the colour of the pileus.

Subsidiary characters not printed on the card for Agaricaceae:

- | | |
|--|---|
| <i>a.</i> Pileus fuscous | <i>m.</i> Spores pip-shaped |
| <i>b.</i> Pileus ferruginous | <i>n.</i> Spores curved-allantoid |
| <i>c.</i> Pileus yellow-brown | <i>o.</i> Spores apiculate |
| <i>d.</i> Pileus olivaceous | <i>p.</i> Spores guttulate |
| <i>e.</i> Pileus fawn or bistre | <i>q.</i> Spores amyloid |
| <i>f.</i> Pileus pallid or off-white | <i>r.</i> Cystidia present |
| <i>g.</i> Gills adnexed | <i>s.</i> Upper surface of pileus tomentose |
| <i>h.</i> Gills emarginate | <i>t.</i> Upper surface of pileus pruinose |
| <i>i.</i> Gills ventricose | <i>u.</i> Upper surface silky or fibrillose |
| <i>j.</i> Gills having irregular edges | <i>v.</i> Flesh blueing on wounding |
| <i>k.</i> Gills having crisped edges | <i>w.</i> Flesh reddening on wounding |
| <i>l.</i> Gills anastomosing or connected by veins | <i>x.</i> Pileus umbilicate |
| | <i>y.</i> Pileus repand |

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Fig. 2 shows the characters included in the key to the Polyporaceae.

Subsidiary characters not printed on key for Polyporaceae:

- | | |
|------------------------------|--------------------------|
| a. Upper surface fawn | d. Upper surface sulcate |
| b. Upper surface ferruginous | e. Upper surface sticky |
| c. Upper surface pallid | |

The characters on which to base the key have been chosen as being those which can generally be determined with minimum delay, and the characteristics of the fungi when grown in culture on agar medium have not been included although in the case of some genera of Polyporaceae, e.g. *Poria* spp., they are very helpful. A similar card key for the identification of cultures of wood-rotting fungi is now in the course of preparation and will be published later if it proves useful. Only by using these keys will their flaws and omissions become apparent, and I shall be grateful for any suggestions or criticisms that occur to other workers.

SUMMARY

A method is described for the preliminary identification of Agaricaceae and Polyporaceae by the use of perforated cards. Specimen cards listing the features used for the diagnosis of species in these two families are illustrated.

This work has been carried out as part of the programme of the Forest Products Research Boards of the Department of Scientific and Industrial Research, by whose permission it is published.

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DOWNY MILDEW DISEASE OF THE CULTIVATED LETTUCE

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A. INTRODUCTION

Mildew of lettuce, caused by *Bremia Lactucae* Regel, is a disease of long standing and one which occurs more or less in all places where lettuce is grown. It has been reported from all continents and from both temperate and tropical regions. The disease is readily recognized and is not likely to be confused with any others which infect the crop, and there has never been any doubt as to the identity of the causal organism. While, therefore, so much is definite, it is somewhat surprising that certain features of the disease are still largely not understood. Thus it is not clear by what means the fungus carries over from one crop to a succeeding one—in particular, it is not known whether the disease is transmitted by means of contaminated or infected seed or by infected residues of earlier crops. Morphologically the same species occurs as a parasite on various composite weeds (groundsel, *Sonchus*, etc.), and it is not certain how far these may function as intermediate hosts.

Again, though the disease is nearly always to be found without difficulty upon growing crops, there is little substantial evidence bearing on the damage which it produces. Affected plants, as a rule, are not killed, and they may in the long run mature satisfactorily. In the language of the cultivator, the plant often 'grows away from the disease', by which is meant that it does not die, but finally produces a saleable lettuce. It does not follow, however, that the effect of the disease is negligible—maturity may be delayed or the size of the mature plant may be reduced. Clear evidence on this point is lacking.

The work described in this paper was carried out over the two seasons 1939-40 and 1940-1 and relates mainly to the points raised in the foregoing paragraphs, viz. the mode of transmission of the disease, and the influence of the disease on the maturing of the crop. Fungicidal methods of control have also been examined. These problems have been studied under the conditions of cultivation which prevail in the market-garden area which lies in the Thames valley west of London, and as the mechanism of disease transmission is obviously related to the methods of cultivation practised, a short account of the latter is desirable.

B. METHODS OF CULTIVATION

Beginning in September, winter lettuce is sown in the open, followed by a later sowing in frames from late October to early November, the latter crop being planted out in spring. These crops mature from about early

May to the middle of June. During approximately the same period, i.e. from September to April, lettuce crops may be grown and matured in frames (cold or heated) or as catch crops in greenhouses. Finally, summer lettuce is sown in the open from March onwards, and these crops mature from July to as late as December, if the early winter is not too severe.

Thus on any market garden in the area round London, there is much overlapping of lettuce crops. It is particularly noteworthy that winter lettuce, which constitutes a fair proportion of the new year's early field crop, overlaps by about two months the last of the preceding year's summer crop. The weather in October–December is often very favourable to mildew, and in fact this disease is often rampant in late summer crops. The new crop cannot always be segregated from such infected earlier crops and therefore there is the possibility of wind-borne spores passing from the one to the other.

My attention was directed chiefly to the incidence of mildew in 'Spring lettuce', i.e. lettuce which is sown in unheated frames in late October or early November and planted out from February to April. In such frames one frequently sees isolated seedlings with one or both cotyledons carrying mildew. These occur sporadically, though later whole areas of the frames may become affected. The first outbreak of the disease thus appears to suggest seed-borne transmission.

C. TRANSMISSION OF MILDEW BY SEED

The method used for investigating the possibility of mildew being seed-borne was as follows. Seed-boxes were dipped for five to ten minutes in boiling water and filled with soil which had been autoclaved for one and a half hours. In order to safeguard against air-borne contamination, the boxes after being seeded were covered with glass plates or bell-jars. In later experiments, an improved device, viz. a large glass-sided frame with closely fitting glass lid, was used. The boxes were freely watered with sterile water, and thus a highly humid atmosphere, favourable to the development of mildew, was provided.

From three to six weeks after sowing, according to the time of year, the seedlings had developed their first two foliage leaves. It could thus be assumed that any seed-borne infection would have had time to produce conidia on the cotyledons, and so the seedlings were removed singly with forceps and examined for the presence of mildew.

In the first five experiments of this kind Trocadero Improved, Imperial and Early French Frame seed of the current year (1939) was used. Later (Exps. VI–VIII) older seed of Trocadero was tested as the 1939 stock may have been unusually clean. The commercial seed so far used may, however, have been harvested from plants which were uninfected by mildew and so in the autumn of 1940 seed was harvested from Imperial, Trocadero, and Winter King plants, the first of which were known to have been heavily infected, but the other two had only been slightly infected and then not at the harvesting period. With the expectation that seed of Imperial mother plants so infected would be most likely to show whether seed-borne

transmission of mildew does or does not occur, four experiments (XI–XIV) were carried out with this seed at various times over the winter of 1940–1.

The data obtained from the fourteen experiments bearing on the question of seed-borne transmission are assembled in Table 1. The results may be summarized as follows:

(1) Imperial, Trocadero and Early French Frame seed of 1939 showed no seed-borne transmission of the disease.

(2) One sowing of commercial Trocadero seed (Exp. VI) contained a small percentage of infected seedlings but the other two did not.

(3) Two experiments (XI and XII) with seed taken from infected mother plants gave slight infection but four did not.

(4) The total number of seedlings examined from October 1939 to May 1941 was 23,755 and of these only 0.025 % were infected with mildew.

Table 1. *The percentage seed infection of lettuce by mildew*

Exp.	Seed sown	Total seedlings	No. infected	% infected seedlings	Variety
I	1. x. 39	1055	0	0	1939 Troc.
II	15. xii. 39	1245	0	0	1939 Imp.
III	15. xii. 39	945	0	0	1939 E.F.F.
IV	15. xii. 39	813	0	0	1939 Troc.
V	25. i. 40	2045	0	0	1939 Imp.
VI	29. iii. 40	1784	3	0.16	1938 Troc.
VII	29. iii. 40	2141	0	0	1938 Troc.
VIII	20. v. 40	946	0	0	1936 Troc.
IX	24. ix. 40	1213	0	0	1940 W. King
X	24. ix. 40	1014	0	0	1940 Troc.
XI	24. ix. 40	699	1	0.14	1940 Imp.
XII	23. x. 40	4069	2	0.05	1940 Imp.
XIII	11. xii. 40	1403	0	0	1940 Imp.
XIV	10. iii. 41	4383	0	0	1940 Imp.

D. TRANSMISSION BY DEBRIS OF INFECTED CROPS

Lettuce frames are often set up in the same place as in the preceding years, and succeeding field crops sown in the same ground, because market gardeners in this area use intensive methods of cultivation and cannot practise a long-term rotation system. It is possible therefore that viable fungal residues may carry the disease over in the field or in frames, particularly in the latter. This brings into consideration the question of resting structures, in particular oospores, and of the viability of mildew conidia.

Oospores of *Bremia Lactucae* were first described by de Bary (1863) but from *Senecio vulgaris* only. References to their occurrence on the cultivated lettuce are given by Smith (1884), Schweizer (1919), Lavrov (1932), and Baudys (1935), and from these it is apparent that oospores are rarely found on that host.

An attempt was made to find them in the debris of lettuce plants which were heavily infected with mildew when alive. Lettuce leaves have a high-water content and a low proportion of lignified tissue, so that they rapidly disintegrate and disappear soon after falling to the ground. If, however, the soil is not too wet they become dry and after a few months in winter are

black and friable. For microscopic examination this type of material was cleared by immersion in a mixture of equal parts of chloral hydrate and pure phenol crystals. These mix on being gently warmed, and on cooling the mixture remains liquid. The fragment of leaf was then placed in 10 % caustic potash solution for a few minutes, washed in several changes of water, stained with aniline blue and finally cleared with lactic acid.

Many slides were prepared in this way from decayed lettuce leaves, but no oospores were seen. On the other hand, recognizable mycelium of *Bremia Lactucae* was almost invariably present, and it is possible that portions of this mycelium may long remain alive.

To test whether soil containing debris from infected plants could infect seedlings, a stock of soil was built up between December 1939 and May 1941 by the continued addition of badly infected leaves to a large box of soil. At intervals some of this soil was removed and about one-third of the sample autoclaved at 15 lb./sq.in. for $1\frac{1}{2}$ hours to be used as control. Commercial seed was then sown in both lots of soil and protected from wind-borne spores as in the experiments described in the previous section. The varieties used were Trocadero and Imperial, the earlier tests having shown that the commercial seed of these varieties did not carry mildew. To encourage development of mildew the humidity was kept at a high level by watering freely with sterile water. After three or four weeks the seedlings were examined for infection, with the results shown in Table 2.

Thus, in all, over 5000 seedlings were grown under conditions highly favourable to the development of mildew, but only one infected seedling was seen. As much debris was present it seems that any viable fungal remains in it were ineffective in transmitting the disease.

Table 2. *Effect of contaminated soil on the occurrence of mildew in lettuce seedlings*

Exp.	Date of sowing	Contaminated soil		Controls		Variety
		No. of plants	% infected	No. of plants	% infected	
I	13. iii. 40	378	0	137	0	Troc.
II	13. iii. 40	859	0.1	256	0	Imp.
III	3. v. 40	2021	0	1562	0	Troc.
IV	8. v. 40	641	0	381	0	Imp.
V	22. x. 40	689	0	311	0	Imp.
VI	9. iv. 41	558	0	879	0	Imp.
	Total	5146	0.02	3526	0	

The possibility of a carry-over by conidia is unlikely but it was desirable to determine the time limit of their viability. For this purpose a number of slides were plentifully dusted with conidia, placed in Petri dishes and kept out of doors at a time when weather conditions were favourable to the development of mildew. On each successive day two slides were moistened with distilled water and twenty-four hours later these were examined for germination. The results from three experiments of this kind are given in Table 3, the figures being the average percentage germination of the conidia for each pair of slides.

Table 3. *Viability of mildew conidia*

	% germination after exposure for							
	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days
Exp. I	53	56	51	7	4	0.8	0	0
Exp. II	68	63	65	13	1	0.7	0.6	0
Exp. III	72	65	62	15	3.5	1.1	0.5	0

Under the prevailing conditions, viability ceased after the sixth or seventh day. It is clear therefore that while conidia remain viable long enough to allow of their being widely dispersed by wind, they cannot transmit the disease over a lengthy time interval.

E. TRANSMISSION BY WEEDS

Bremia Lactucae occurs on a large number of composite genera such as *Sonchus*, *Tragopogon*, *Crepis*, *Senecio* and *Hieracium*, and these include many common species of weeds which may provide a source of infection of the cultivated lettuce.

In the autumn of 1940 seeds were collected from the following composite weeds: *Sonchus oleraceus*, *Tragopogon*, *Hieracium Pilosella*, *H. murorum*, *Lactuca muralis*, *L. Scariola*, *L. saligna*, *Senecio Jacobaea* and *S. vulgaris*. Seeds of these were sown under glass in September 1940 and grown to the three- or four-leaf stage, after which they were sprayed with a suspension of *Bremia* spores from cultivated lettuce by means of an atomizer. *Lactuca saligna* and *L. Scariola* only developed mildew lesions. A repetition of the experiment gave the same result, and the infections were successfully transferred from the wild species of *Lactuca* back to healthy cultivated lettuces.

Later, mildew was found occurring naturally on *Senecio Jacobaea* and this was transferred to *S. vulgaris* seedlings but it failed to infect the cultivated lettuce. *Bremia* found on *Senecio vulgaris* in the field behaved in a similar way, i.e. it infected *S. Jacobaea* but not the cultivated lettuce.

Bremia, therefore, though morphologically uniform, has various biological races. These different races show some specific choice of a host, e.g. *Lactuca muralis* was not infected by conidia taken from *L. saligna*, *L. Scariola*, or the cultivated lettuce.

It appears therefore that, of the wild hosts examined, *L. Scariola* and *L. saligna* are the only ones which are capable of transmitting mildew to lettuce. As both these are uncommon in England, they cannot be of any importance in this connexion.

The conclusions to be drawn from sections C, D and E are on the whole negative and therefore the only plausible hypothesis is that each lettuce crop is infected from a previous one. The implications of this will be discussed later.

F. IMPORTANCE OF THE DISEASE

Repeated observations of mildewed plants show that they become more susceptible to secondary attacks of the more important *Botrytis* disease. Mildew lesions on the outer leaves of more or less fully grown lettuce plants

become senescent and *Botrytis* invades the leaves from these areas. Usually, however, mildewed plants do not succumb, but mature in due course. Damage therefore is to be assessed by comparing the performance in the field of mildewed seedlings with that of uninfected seedlings of the same age and cultural treatment. This type of experiment would not have much practical significance if the grower were able to discard all infected seedlings when planting out, but mildew is often so widespread in the frame that selection is not possible, and plants with very small or incipient lesions could not be sorted out.

Eight plots of lettuce were planted out from Dutch lights on 28 February 1941, each plot consisting of four rows of fifteen plants. The odd and even plots consisted of mildew-free and mildewed seedlings respectively, and all the plants were, as far as could be seen, free from infection by *Botrytis* and *Rhizoctonia*. Care was taken to see that all the plants were of uniform size. The survival figures for each plot were noted on 30 April and 2 June 1941, and these are shown in Table 4.

Table 4. *Effect of mildew on survival of lettuce*

Plot	Seedlings	Plants per plot		
		28 Feb.	30 Apr.	2 June
I	No mildew	60	56	52
II	Mildewed	60	37	32
III	No mildew	60	47	40
IV	Mildewed	60	35	31
V	No mildew	60	44	42
VI	Mildewed	60	37	32
VII	No mildew	60	56	54
VIII	Mildewed	60	45	43
Totals	Free from mildew	240	203	188
	Mildewed	240	154	139

The presence of mildew thus causes a material increase in the mortality of the plants, due in this experiment as usual to *Botrytis cinerea*.

The cutting record of this crop is shown in Table 5.

Table 5. *Numbers of lettuce matured at various dates*

Plot	Seedlings	No. of lettuce cut				
		6 June	12 June	16 June	19 June	Residue
I	No mildew	31	8	10	1	2
II	Mildewed	11	6	10	3	2
III	No mildew	31	4	0	3	2
IV	Mildewed	9	8	7	5	2
V	No mildew	29	5	3	2	1
VI	Mildewed	9	10	6	7	1
VII	No mildew	37	7	4	3	2
VIII	Mildewed	21	12	3	5	0
Totals	Free from mildew	128	24	17	9	7
	Mildewed	50	36	26	20	5

By the method of linear interpolation, one can determine approximately the dates at which 75 % of the two lots of plants matured. These are 8 and 14 June for the plants from non-mildewed and mildewed seedlings

respectively. This represents a check to maturing of about six days, which is an item of importance to the growers of spring lettuce.

G. CONTROL BY MEANS OF RESISTANT VARIETIES

Workers in several countries have claimed that lettuce shows varietal resistance to mildew. Jagger and Chandler (1932) demonstrated that immunity is a Mendelian dominant and named eight resistant varieties. According to Macpherson (1932) the English varieties Loos Tennis Ball, Rosy Spring, and May Queen are resistant.

For the purposes of testing, seedlings three weeks old and of comparable size were evenly spaced in pots. There were ten seedlings per pot and ten pots of each variety. They were then inoculated with mildew spores under identical conditions, as follows. A suspension of fresh spores was put in a type H₃ Aerograph spray gun, constant pressure provided by a hand pump supplying air at 15 lb./sq.in. and the nozzle pointed horizontally at the seedlings with its tip at a distance of 9 in. from the near edge of the pot. Each pot was sprayed for one second.

Table 6 gives the percentage of infected plants in an experiment with nine commonly grown varieties.

Table 6. *Varietal susceptibility to mildew*

Variety	% infection	Variety	% infection
Lees' Immense	1.1	Cheshunt Early Giant	20.0
Trocadero	2.5	Arctic King	21.3
Market Favourite	6.3	Blackpool	21.3
Feltham King	12.9	Early French Frame	40.0
Imperial	15.0		

On analysing the data obtained in this experiment by the method of Bliss (1937, 1938), the following conclusions were drawn:

(1) Lees' Immense is significantly more resistant than Feltham King and all other varieties below it in the table.

(2) All the varieties are significantly more resistant than Early French Frame.

(3) Trocadero and Market Favourite are significantly more resistant than all the remaining varieties except Feltham King and Imperial.

In experiments which will be described later, the varieties Trocadero and Imperial, which would be classed respectively as resistant and moderately resistant on the basis of the results in Table 6, gave over 90 % of infected plants. Thus it is seen that, although there is a measure of variation in resistance between varieties, all those used by the writer have shown heavy infection under conditions favourable to the development of mildew. The choice of resistant varieties is not likely therefore to eliminate infection by mildew.

H. EFFECT OF VENTILATION OF FRAMES

That high humidity favours the disease is unquestioned and this was borne out by my experience in inoculating lettuce seedlings with mildew throughout this work. Growers accept this view and accordingly give as much

ventilation as the atmospheric conditions permit. Thus it is good practice, in the management of frames, to remove the covers completely on dry non-frosty days, and to allow a certain amount of ventilation at night, in all but severe weather, by propping up the covers. It is true that other considerations apply, e.g. this procedure is believed to give some protection against *Botrytis* disease. Also complete removal of lights whenever possible allows of better illumination, so that hardier, stockier, more frost-resistant seedlings are produced.

Though so much is accepted, there is little quantitative evidence that humidity influences the spread of mildew; consequently the following experiment was devised. Two pots of similar size, each containing ten seedlings heavily infected with mildew were placed in the centre of neighbouring frames. Twenty pots, each containing ten healthy, three-week Imperial seedlings were placed round these pots at a distance of 2 ft. Both frames were then kept shut and one watered every day, the other not at all. After twenty-three days mildew lesions were noticed and the percentage infection determined. That in the watered frame was 61.4 % and that in the unwatered frame was 11.3 %. Between 27 March and 9 April 1941 the experiment was repeated and the results were:

Watered frame	38.6 % infection
Unwatered frame	0.0 % infection

These results are very clear-cut but though the humidity of the watered frame was certainly higher than that of the dry one some of the spread of the disease may have been due to the draughts and splashing caused by watering.

Whether the opening of the frames be good or bad from the point of view of draughts, it is certain that during spells of very humid, muggy weather opening of the frames cannot reduce the humidity to the safety level. The fact that mildew does appear in quantity both in frames and out of doors, especially in mild wet winters, is evidence that the ventilation method, even if it is useful, does not give adequate control under conditions which are highly favourable to the disease.

I. FUNGICIDAL CONTROL

Experiments on this subject were carried out over the period November 1939 to April 1941. The general plan was as follows. For each treatment ten pots were set up, each containing ten three-week seedlings. These were hardened off and then sprayed or dusted with the appropriate fungicide. Next day they were inoculated with a suspension of *Bremia* conidia. The inoculum was prepared in tap water by brushing off spores from fresh mildew lesions with a wet camel-hair brush. Examination of a drop under the microscope showed whether it was concentrated enough, and usually it was filtered through butter muslin to remove conidiophores and dirt.

In 1939-40 the inoculations and sprays were applied with a small scent-spray atomizer but in 1940-1 a type HS Aerograph spray gun with a

de Vilbiss nozzle was substituted since it gave a more constant and finely divided spray. The air pressure of 15–20 lb./sq.in. required for the operation of the atomizer or spray gun was provided by a small hand pump. Dusts were applied with an apparatus specially constructed to give an even flow of dust into a chamber of known area containing the pots to be dusted.

The pots of seedlings, after treatment with fungicide and spraying with spores, were randomized in a cold frame which was kept closed. After some days, varying in number with the temperature, but usually about twelve, conidia had developed on the leaves. Each seedling, which had by this time at least four leaves including the cotyledons, was examined and the number of infected and uninfected leaves noted. At the same time the amount of phytocidal damage was assessed for each pot according to an arbitrary scale, the figures 0, 1, 2, 3 corresponding respectively to 'no damage', 'just visible flecking', 'fairly general spotting' and 'development of considerable necrotic areas'. The highest figure obtainable in any experiment of ten pots was therefore thirty. Records of maximum and minimum temperatures were kept throughout the experiments.

Experiment I, begun on 12 November 1939, contained nine treatments:

- (1) 5 % red copper oxide with talc as filler and applied as a dust at the rate of 0.25 oz./sq.yd.
- (2) 5 % red copper oxide with Folosan (pentachloronitrobenzene) as filler, 0.25 oz./sq.yd.
- (3) $\frac{1}{2}$ lb. red copper oxide, $\frac{1}{2}$ gal. cotton-seed oil, and 1 quart of lethalate spreader made up in 50 gal. of water.
- (4) 2 : 2 : 40 Bordeaux mixture as a spray.
- (5) Folosan as a dust at 0.25 oz./sq.yd.
- (6) Folosan with lime as filler at 0.25 oz./sq.yd.
- (7) Flowers of sulphur as a dust at 0.25 oz./sq.yd.
- (8) Pure calcium hydroxide dust at 0.25 oz./sq.yd.
- (9) Control.

Bordeaux mixture was included because of its successful use at this strength for the control of mildew by Osmun (1934), the copper oxide sprays and dusts because of the work done by Clayton (1938*b*) in the control of downy mildew of tobacco, and the Folosan because of its control of *Botrytis* disease of lettuce as demonstrated by Smieton and Brown (1940). Lime was included because some growers use it in the hope of reducing mildew.

The results of this experiment are given in Table 7 and may be summarized as follows:

- (1) Lime is of no value.
- (2) Sulphur, though it causes no injury, gives poor protection.
- (3) Folosan, with talc filler, gives fair control and is safe; on the other hand, the incorporation of lime as filler more or less completely takes away its fungicidal value.
- (4) All the preparations containing copper give a pronounced measure of control, but those containing copper oxide (Cu_2O) have rather a pronounced phytocidal effect. The best control is given by 2 : 2 : 40 Bordeaux mixture.

Table 7. *Effect of fungicides on the control of lettuce mildew*

Treatment	Plants		Leaves		Estimated damage
	Total	% infected	Total	% infected	
(1) Copper oxide + talc	192	0.0	746	0.0	14
(2) Copper oxide + Folosan	197	1.5	795	0.4	10
(3) Copper oxide spray	232	1.7	887	0.5	9
(4) 2 : 2 : 40 Bordeaux	205	2.5	794	0.8	2
(5) Folosan	207	13.1	804	5.2	0
(6) Folosan lime	214	78.0	803	36.4	0
(7) Lime dust	274	92.7	1018	57.9	0
(8) Sulphur dust	224	40.6	841	19.7	0
(9) Controls	213	87.9	789	49.8	0

Average minimum temperature = 41.0° F.

Experiment II. This was essentially a repetition, in duplicate frames, of the preceding. It was begun on 19 December 1939, but was not concluded until 25 January 1940 on account of the very slow development of mildew. During this period the exceptionally cold spell of the winter of 1939-40 began. This led to considerable winter-killing by frost, in spite of the protection afforded by the frames. The data of Table 8 show that this effect was accentuated by the use of fungicides, and in particular by certain of the copper-containing preparations. Of these, dilute Bordeaux mixture was, as in Table 7, the least damaging.

Table 8. *Mortality of lettuce seedlings due to frost*

Treatment	Exp. A	Exp. B
	% mortality	% mortality
(1) Copper oxide + talc	55	50
(2) Copper oxide + Folosan	65	65
(3) Copper oxide spray	69	55
(4) 2 : 2 : 40 Bordeaux	40	42
(5) Folosan + talc	48	50
(6) Folosan + lime	42	41
(7) Lime	39	29
(8) Sulphur	31	30
(9) Control	37	31
Av. min. temp.	26.5° F.	25.2° F.

In further experiments during 1940-1 sprays only were used, and the list of these is as follows:

(1) *Cuprous oxide*. 'Cuprocide 54', a commercial preparation containing 50% Cu_2O with incorporated spreader, was used at strengths of 2, 1, 0.5 g./l.

(2) *Bordeaux mixture* of compositions 1 : 1 : 40, 2 : 2 : 40 and 4 : 4 : 40.

(3) *Excess-Lime Bordeaux* (2 : 10 : 40). The fungicidal efficiency of this preparation has been demonstrated by Grubb (1924).

(4) *Sodium orthophosphate-copper sulphate spray*. Bruno (1940) gives the formula for a copper fungicide as: 1 kg. copper sulphate in 50 l. of water, and 1.25-1.30 kg. sodium orthophosphate in 20-30 l. of water, made up to 100 l. in water. He claims that it is more dispersible than Bordeaux mixture. This spray contains approximately the amount of copper present in a 4 : 4 : 40 Bordeaux mixture. For use on lettuce it was reduced to half the strength advised by Bruno to make it comparable with a 2 : 2 : 40 Bordeaux mixture. Sodium orthophosphate, unlike lime, dissolves completely in water, and the precipitate formed when copper sulphate is added

is finely divided and flocculent. This fungicide therefore gives a more even dispersion of small particles over the leaf surface than does Bordeaux mixture.

(5) *Bouisol* at the rate of 1 lb. to 30 gal. of water. At first the spreader Agral 2 (0.05 %) was added to the Bouisol but was later left out as it was found to increase damage.

(6) *Salicylanilide* at the rate of 10 oz./40 gal. of water with 0.05 % Agral 2 as a spreader.

Table 9

Experiment	I		II		III		IV		V	
Date: From	13. x. 40		16. x. 40		5. xi. 40		28. xi. 40		28. xi. 40	
To	31. x. 40		1. xi. 40		19. xi. 40		9. i. 41		17. i. 41	
Average min. temp. ° F.	34.0		36.0		35.1		29.5		31.0	
Fungicide	E.D.	% inf.	E.D.	% inf.	E.D.	% inf.	E.D.	% inf.	E.D.	% inf.
$\frac{1}{4}$ strength Cuprocide	0	20.6	—	—	—	—	—	—	—	—
$\frac{1}{2}$ strength Cuprocide	1	13	0	18.1	0	2	—	—	3.5	0
Full strength Cuprocide	3	21.8	1	18.7	2	10	7.5	2	6	0
1 : 1 : 40 Bordeaux mixture	2	7.1	0	2.1	2	1.2	18	2	11	0
2 : 2 : 40 Bordeaux mixture	5	1	2	1	5	0	24	1.1	12	0
4 : 4 : 40 Bordeaux mixture	5	1.2	3	0	6	0	21	0	14	0
Excess-Lime Bordeaux	—	—	—	—	—	—	10.5	2	—	—
Orthophosphate-copper spray	—	—	—	—	—	—	—	—	—	—
Bouisol	—	—	—	—	—	—	—	—	—	—
Bouisol + Agral 2	—	—	—	—	6	0	22	0	23	0
Salicylanilide + Agral 2	—	—	0	40.8	—	—	—	—	—	—
Control	0	53	0	46.8	0	4	4	53.1	0	10

Experiment	VI		VII		VIII		IX	
Date: From	24. i. 41		28. ii. 41		21. iii. 41		9. iv. 41	
To	25. ii. 41		18. iii. 41		4. iv. 41		23. iv. 41	
Average min. temp. ° F.	34.0		35.2		37.9		39.0	
Fungicide	E.D.	% inf.	E.D.	% inf.	E.D.	% inf.	E.D.	% inf.
$\frac{1}{4}$ strength Cuprocide	—	—	—	—	—	—	—	—
$\frac{1}{2}$ strength Cuprocide	—	—	—	—	—	—	—	—
Full strength Cuprocide	2	0	0	0	0	1	0	12
1 : 1 : 40 Bordeaux mixture	4.5	0	0.5	0	1.5	2	0	15
2 : 2 : 40 Bordeaux mixture	3.5	0	0	2	3.5	0	0	16
4 : 4 : 40 Bordeaux mixture	4	1	0.5	1.1	1.5	5	0	18
Excess-Lime Bordeaux	0	1	0	2	1	1	—	—
Orthophosphate-copper spray	0.5	1	0	1	0	0	0	13
Bouisol	3	0	0	0	3.5	0	0.5	12
Bouisol + Agral 2	2.5	0	—	—	—	—	—	—
Salicylanilide + Agral 2	—	—	—	—	—	—	—	—
Control	0	33.8	0	61.9	0	72.6	0	96

E.D. estimated damage.

Table 9 shows the relation between fungicidal efficiency, damage, and average minimum temperature. The following are the conclusions from this table.

(1) The amount of damage increases as the average minimum temperature falls.

(2) The damage varies with the fungicide.

(3) As the strength of the Bordeaux increases there is no marked increase either in fungicidal effect or phytocidal damage though on the whole 2 : 2 : 40 Bordeaux gives the best control.

(4) Cuprocid 54 is somewhat safer at low temperatures than Bordeaux 2 : 2 : 40 and in addition it is just as effective as a fungicide.

(5) Bouisol at the strength used (1 lb. to 30 gal. of water) has no advantage over Bordeaux as a control and causes more damage.

(6) 2 : 10 : 40 Excess-Lime Bordeaux causes less damage than 2 : 2 : 40 Bordeaux mixture but its efficiency as a fungicide may be a little less.

(7) The sodium orthophosphate-copper sulphate spray, over the short period during which it was used, proved as efficient as 2 : 2 : 40 Bordeaux and also caused less damage.

(8) Salicylanilide + Agral 2 (5 %) gives a poor control of mildew.

The experiments so far described were carried out under conditions which were highly favourable to the development of mildew. In the course of the work three experiments under ordinary conditions of practice, except that the plants were uniformly inoculated at a young stage by spraying with spores, gave the results which are summarized below.

Experiment 1, with fifteen Dutch lights each containing forty-eight Imperial seedlings (23 Feb.-3 April 1940). Treatments: Control; Cuprocid 54 ($\frac{1}{2}$ lb. to 50 gal. water); Bordeaux mixture 1 : 1 : 40, 2 : 2 : 40 (with or without Folosan), 4 : 4 : 40. Two sprayings were applied. All treatments gave good control of mildew, the controls showing considerable infection in the young stages. The experiment was concluded when the plants were about half-grown, at which time there was no evidence of difference between controls and treatment in respect of numbers of survivors or weight of plants. This was apart from some check to growth where Folosan had been used.

Experiment 2, with six Dutch lights (4 Nov. 1940-13 May 1941). Treatments: Control; Bordeaux mixture 2 : 2 : 40 and 4 : 4 : 40. Three sprayings were applied. Conditions in early winter were not favourable to severe infestation of the controls. At the time of maturity there was no difference in any respect between treated and untreated plants.

Experiment 3, with sixteen Dutch lights (17 Dec. 1940-12 June 1941). Treatments: Control; Bordeaux 2 : 2 : 40; Cuprocid 54 (1 lb. to 50 gal. water); Bouisol (1 lb. to 30 gal. water). Two sprayings were applied. By mid-February heavy infestation of the untreated frames was shown, the treatments and especially 2 : 2 : 40 Bordeaux showing good control. Seventy-two plants from each treatment were set out in replicated plots in the open ground on 18 Feb. and carried to maturity. The differences in survival and in average mature weight were negligible, but there was a delay of five days in the maturing of the untreated plants. This amount may be of significance to the practical grower, at least at certain seasons.

Attempts to use the vapour method which has proved successful in the control of tobacco mildew (blue mould), viz. to use paradichlorbenzene as recommended by Clayton (1938*a, b*) or benzene mixed with lubricating oil as recommended by Wolf *et al.* (1939, 1940) have given very unsatisfactory control of lettuce mildew and do not appear at all promising.

J. EFFECT OF pH ON GERMINATION OF *BREMIA CONIDIA*

The preliminary experiments in the section on fungicidal control include hydrated lime, as lettuce growers consider that it gives some control of

lettuce mildew. The results obtained show that lime is of no value whatever as a fungicide in this instance, and infection on lime-dusted plants is at least as heavy as on controls, if not heavier, the comparative percentage infections being:

Lime, 92.7 %, 98 %. Control, 87.9 %, 93 %.

Laboratory experiments on the germination of *Bremia* spores on lime-dusted slides showed that, as expected, lime dust had no effect on the germination. Both controls and dusted slides had germinations varying between seventy and eighty per cent. This shows that *Bremia* conidia are able to germinate in alkaline solutions. The effect of pH on germination is shown more fully in Table 10.

Table 10. *Effect of pH on the germination of conidia*

pH	% germination	
	Exp. A	Exp. B
9.6	73	65
8.0	67	76
6.4	53	62
3.9	22	34
2.2	12	5

Both experiments agree in showing that germination is reduced in distinctly acid solutions but takes place freely in alkaline solutions. The pH of saturated lime solution however is greater than 9.6 and so is outside their range. Titration with hydrochloric acid by the standard method gave the normality of saturated lime solution as *N*/34. Further experiments showed that germination falls off sharply beyond this point and that it is inhibited in *N*/10 sodium hydroxide. On the acid side germination begins to be affected in concentrations of HCl exceeding 1 in 10,000 *N*.

K. SUMMARY

1. Lettuce seedlings, grown from both ordinary commercial seed and seed from mother plants known to be infected with mildew, almost invariably failed to show symptoms of the disease under conditions favourable to mildew development. There was thus negligible evidence of the seed-borne transmission of mildew.
2. Oospores were not found by the microscopical examination of debris from infected plants, and seedlings grown in soil containing a high proportion of such debris for a period considered to be adequate, under favourable conditions for the development of mildew, did not become infected. The transmission of the disease by contaminated soil is therefore unlikely.
3. Attempts to transmit mildew from composite weeds to lettuce were successful only with some wild species of *Lactuca*. These species are probably too rare to be important in the spread of the disease.
4. The survival of mildewed lettuce was lower, and their date of maturity later, than that of healthy plants. This, together with the disfigurement caused by the disease, gives it its commercial importance.

5. A number of commercial lettuce varieties commonly grown in England showed varietal differences in their susceptibility to the pathogen but these differences were not sufficiently marked to make the exclusive cultivation of the more resistant varieties worth while as a control measure.

6. 2 : 2 : 40 Bordeaux mixture, Excess-Lime Bordeaux (2 : 10 : 40), an orthophosphate copper spray, and Cuprocide 54 (1 lb. to 50 gal.) all gave adequate protection from mildew disease but sprays containing no copper such as lime sulphur and pentachloronitrobenzene did not. All the copper-containing sprays are liable to produce phytocidal damage, particularly in cold weather.

7. Fungicidal vapours such as benzol and paradichlorbenzene were troublesome to use and gave a poor control of lettuce mildew.

8. *Bremia* conidia under favourable temperature conditions germinated readily in saturated lime solution and were also found to germinate more readily in slightly alkaline than in slightly acid solution.

I wish to thank Prof. W. Brown, F.R.S., who suggested this investigation and under whose supervision it was carried out.

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A *VERTICILLIUM* DISEASE OF CULTIVATED MUSHROOMS NEW TO GREAT BRITAIN

By FRED. C. ATKINS

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A new species of *Verticillium* attacking the brown strain of the cultivated mushroom, *Psalliota* (*Agaricus*) *campestris* (L.) Fr., was recently described in Copenhagen by Treschow (1941), who named it *Verticillium Psalliotae*. The same species was noticed at Yaxley in January 1946, attacking the white strain of the cultivated mushroom; and other specimens have since been seen at Thornham, Norfolk. On 29 January 1946, during the course of routine examinations of diseased mushrooms which modern commercial practice demands (Atkins, 1945), one specimen with a light brown, roughly circular patch on the pileus was found, as expected, to be attacked by a *Verticillium*, but the species differed radically from *V. Malthousei* Ware (1933) in that the conidia were invariably pointed at each end, and they were borne transversally on the phialides. Commercial practice compelled the removal of the diseased mushroom from the bed, but cultures were made in the laboratory. Three more similarly infected mushrooms were found in succeeding weeks, and detailed examination by Mr McG. Bulloch and myself revealed close similarity to *V. Psalliotae*, which Treschow found in the summer of 1939.

Treschow (1941) stated that the pathogenicity of both *V. Malthousei* and *V. Psalliotae* was confined to the brown strain. This contention is certainly invalid with regard to *V. Malthousei*, as Ware (1933) has demonstrated; and from the appearances at Yaxley it appears that the white strain is also attacked by *V. Psalliotae*. We sent cultures of our fungus to Dr Treschow, and after a preliminary examination he tells me he is unable to find any difference between it and *V. Psalliotae*. He found that the appearance of the strain, the position of the branches, and the size, as well as the characteristic red colouring matter formed in the substratum, were identical.

White mushrooms at Yaxley have been successfully inoculated with the disease by applying drops from a washing in sterile water of a malt agar slope culture. Vigorous growth of mycelium was visible to the naked eye after forty-eight hours at 20° C.

The disease is now being investigated further by Dr C. J. LaTouche, Microbiologist with the Mushroom Research Association at Yaxley. Preliminary observations reveal that the mould, when grown on 2 % malt agar (pH 5.5) at fluctuating laboratory temperatures, produced an abundant floccose snow-white aerial mycelium which was compacted to form a thin skin at the surface of the medium. It developed a pigment (Van Dyke Red, Ridgway) in the medium, as Treschow found. Aerial

mycelium from a three-weeks-old culture on malt agar, mounted in lactophenol and cotton blue, revealed the following characteristics:

Hyphae septate, branched, about 1μ broad. Fertile hyphae bearing more than four verticils of phialides, which in turn vary in number from two to five, measure $12.5-31.5\mu$ long by a maximum of 1μ broad, and taper to a fine point. Conidia aseptate, more or less straight on the attached side and somewhat convex on the other, pointed at both ends, $4.3-12.9\mu \times 1.75-2.15\mu$ broad (compared with Treschow's measurements of $6-10.5\mu \times 2-3.5\mu$).

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(Accepted for publication 31 December 1946)

STUDIES ON BRITISH CHYTRIDS

III. *ZYGORHIZIDIUM WILLEI* LOWENTHAL AND
RHIZOPHIDIUM COLUMNARIS N.SP.

By HILDA M. CANTER, B.Sc.

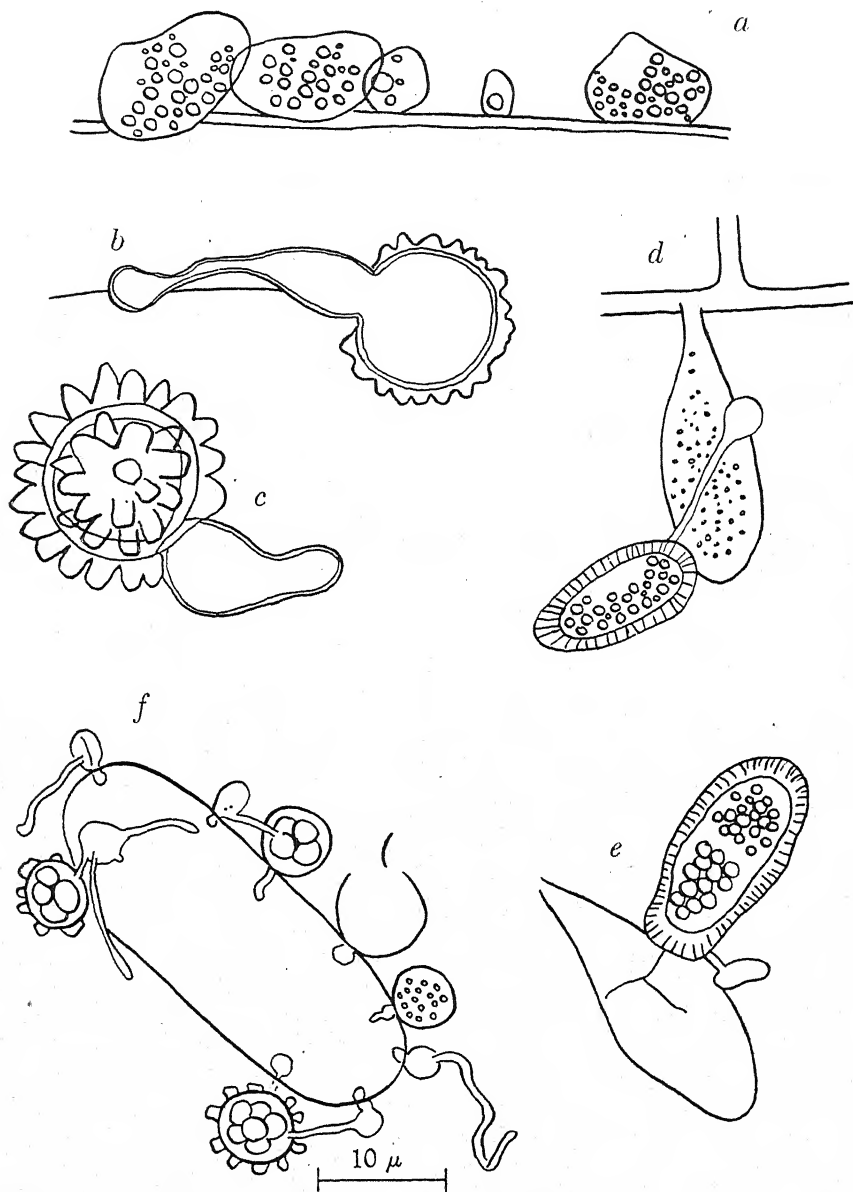
*The Freshwater Biological Laboratory, Wray Castle, Ambleside, and
Department of Botany, Birkbeck College, London*

(With Plate XI and 4 Text-figures)

The genus *Zygorhizidium* was erected by Löwenthal (1905) for an epibiotic operculate chytrid, distinguished from *Chytridium* by possessing a resting spore formed as the result of a sexual process. The type of sexual reproduction exhibited by *Zygorhizidium* is well known. A small male thallus puts out a conjugation tube which grows until it makes lateral contact with the wall of a larger female thallus. Fusion occurs and the contents of the male pass into the female, which later becomes the resting spore. In addition to Löwenthal's observations on *Z. Willei*, it has been described by Scherffel (1925) and Domján (1936). *Z. verrucosum* Geitler (1942) has an identical sexual process (Text-fig. 1f).

This type of sexual reproduction has again been observed in *Chytridium Characii* Scherffel (1925). The mature resting spore is ovoid, with its long axis at right angles to the host cell. The outer layer of the wall is thicker at the base and apex than in the middle region, and in surface view is covered by longitudinal rows of elongate warts (Text-fig. 1d, e). Although the method of formation of this resting spore is so strikingly like that of *Zygorhizidium*, the exact position of *Chytridium Characii* remains obscure since no zoosporangia were observed. The conjugation tube in the three organisms mentioned above is characterized by remaining equally cylindrical throughout its length. Scherffel (1925) describes *Chytridium? Spirotaenia*, in which the conjugation tube swells at its point of contact with the female, and becomes club-shaped (Text-fig. 1b). Thus when the male and female thalli are close together, the narrow middle portion is lost, and the conjugation tube forms an irregular vesicular structure (Text-fig. 1c). Once again the exact affinities of this organism are unknown, since dehiscence of the zoosporangium was never seen. The structure of the resting spore wall, with its outer surface covered with spines, consisting of refractive wall material, somewhat resembles *Zygorhizidium verrucosum*, and the type of sexuality may be regarded as a variant of that found in *Zygorhizidium*.

A few examples of *Z. Willei*, hitherto unknown from this country, were found growing on *Mougeotia* sp. in a collection from Montreal Park Lake, Sevenoaks, Kent, England, in March 1945. Little doubt remains as to the identity of this fungus although dehiscence of the zoosporangium was not



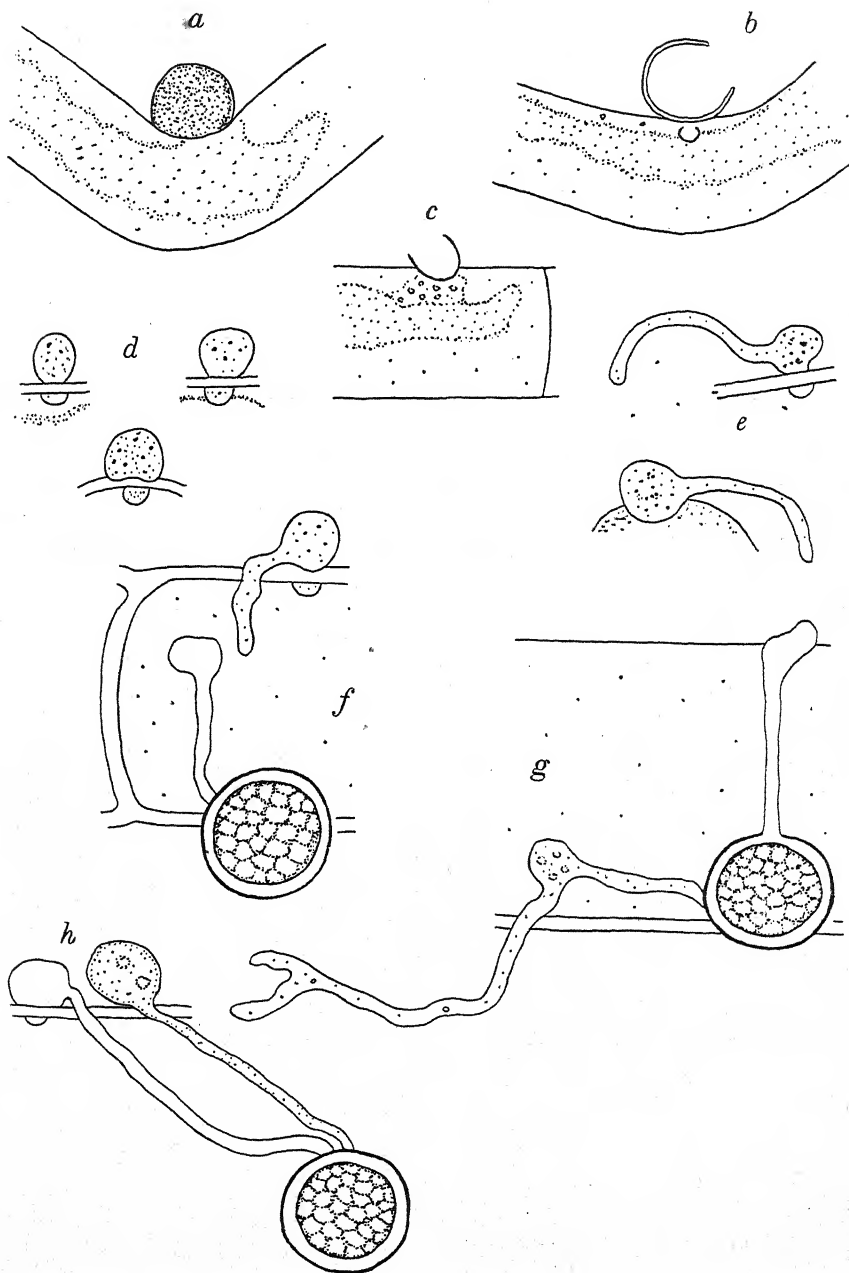
Text-fig. 1. *a-c*, *Chytridium Spirotaeniae* Scherffel. *a*, zoosporangia; *b*, *c*, sexually formed resting spores; in *c*, the middle cylindrical portion of the conjugation tube is lost, it therefore forms a swollen vesicular structure; *d*, *e*, resting spores of *Chytridium Characii* Scherffel; *f*, *Zygorhizidium verrucosum* Geitler. (*a-e*, after Scherffel (1925); *f*, after Geitler (1942).)

seen, since the shape of the sporangia and the peculiar method of sexual reproduction agree perfectly with Löwenthal's original description of *Zygorhizidium Willei* on *Cylindrocystis Brebissonii*, from Norway.

The fungus is parasitic, but rarely produces more than a slight disorganization of the host chloroplast. Large sporangia 17μ in diameter may bring about a curvature of the *Mougeotia* cell as reported previously by Scherffel (1925), but this is not a constant feature, and dwarf sporangia ($5\text{--}6.6\mu$ in diameter) caused no distortion of the filament. The intramatrix rhizoidal system consists of a knob-like structure apparently devoid of rhizoids (Text-fig. 2*b*). In some specimens it seemed to be absent, but more probably it was merely obscured by the chloroplast of the host cell. Zoospores were observed only once, and were of the usual chytridiaceous type.

After the material had been left in the laboratory for about four weeks, sexually formed resting spores appeared (Text-fig. 2*f-h*). The male thallus (Pl. XI, fig. 2), is ovoid and possesses an endobiotic knob devoid of rhizoids. The conjugation tube from the male thallus often branches, and may reach a length of 33μ . Contact is made with a larger subspherical receptive thallus whose endobiotic knob also lacks rhizoids. In several instances two conjugation tubes approached the receptive thallus (Text-fig. 2*h*), but the one which had fused with it could be detected by its lack of contents. The resting spore is spherical, 11μ in diameter, with a thick smooth wall, brownish in colour, surrounding the central highly refractive globular contents; germination was not observed.

In late August 1946 a chytrid, at first believed to be *Chytridium?* *Spirotaenia* Scherffel, was found parasitizing *Spirotaenia condensata* Bréb. in the Clay Pond, Wray Castle. The fungus appears to be specific to its host, since other Conjugales, *Mougeotia*, *Zygnema* and *Closterium* spp., although present, were not attacked. The epibiotic sporangium is usually broadly ovoid, very rarely spherical, with its longer axis parallel to the algal wall (Text-fig. 3*b-f*). A small conical protuberance, probably representing an unexpanded portion of the original zoospore case, can usually be found on the upper surface of each sporangium (Text-fig. 3*c*). The contents of the latter are in young stages mainly centralized, with a few scattered globules in the hyaline peripheral region. Later the content becomes evenly granular, and the subsequent changes in the protoplasm leading to the formation of zoospores are similar to those described for the majority of chytrids. The rhizoidal system where visible is not extensive and consists of a tuft of branched structures arising close together, so that no distinct main rhizoidal axis is produced (Text-fig. 3*c, d*). The mature sporangia vary from 25 to 63μ broad \times 16 to 27μ high; a few extremely small ones rather more spherical were encountered $8\text{--}15\mu$ broad \times $9\text{--}13\mu$ high. The number of zoospores produced in a mature sporangium varies according to its size. A small one liberates about fifteen zoospores, whereas up to one hundred are formed in a large sporangium. The sporangium wall gradually deliquesces, and two oppositely placed, broad dehiscence pores appear (Text-fig. 3*e, f*). The uniflagellate zoospores emerge singly, and swim away with a smooth gliding movement. They are spherical, 2.6μ in



Text-fig. 2. *Zygorhizidium Willeyi*. *a*, immature sporangium on *Mougeotia*. *b*, dehiscent sporangium with indications of a knob-like rhizoid. *c*, an empty small sporangium. *d*, young female thalli. *e*, developing male thalli. *f-h*, mature resting spores; in *h*, two male thalli are connected with one resting spore. (*a-c*, $\times 660$; *d-h*, $\times 1400$.)

diameter, with a conspicuous anterior oil globule and a darker area to one side of it.

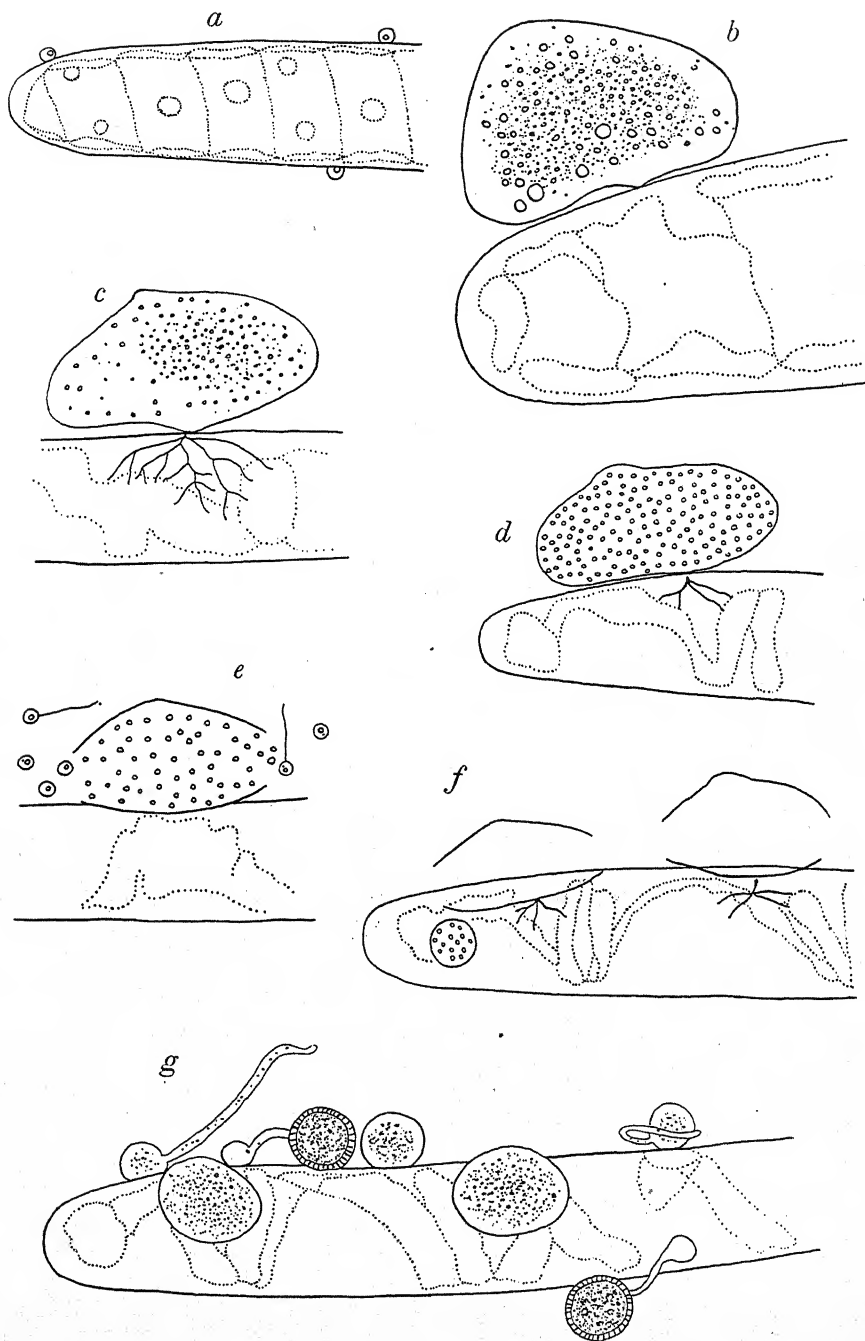
The resting spore is produced after a sexual process identical with that found in *Zygorhizidium*. The spherical male thallus puts out a narrow conjugation tube about 2μ in diameter, up to 38μ long, which grows until it reaches a female thallus (Text-figs. 3g, 4h-k, n and Pl. XI, fig. 5). The latter is also spherical, slightly larger than the male and having a broader base. The rhizoids of these thalli can rarely be distinguished. Presumably, following fusion, the wall of the female thickens (up to 3μ diameter) and columnar bands of highly refractive wall material develop. These extra thickening bands are internal to the spore wall, which retains its smooth outline (Text-figs. 3g, 4h, n and Pl. XI, fig. 4). The mature resting spore is spherical, $10-20\mu$ in diameter, with granular contents; its germination was not observed.

As mentioned earlier (p. 130) this chytrid shows a striking resemblance to *Chytridium Spirotaenia*. The shape of the zoosporangium, with its conical protuberance on the upper surface, is similar, as is also the method of sexual reproduction by conjugation. However, there are certain differences. The sporangium is much smaller, opening by a single apical or lateral pore, and not by two lateral oppositely placed pores as is characteristic for *Rhizophidium columnaris*. Also in *Chytridium Spirotaenia* the male conjugation tube swells at its point of contact with the female, and the outer layer of the resting spore wall is densely covered with broad, solid, refractive, ray-like protuberances, giving it an irregular outline (Text-fig. 1b, c). In view of these differences it is suggested that these two organisms cannot be recognized as identical, and a new species is erected, *Rhizophidium columnaris*, taking its name from the columnar bands of thickening on the resting spore wall.

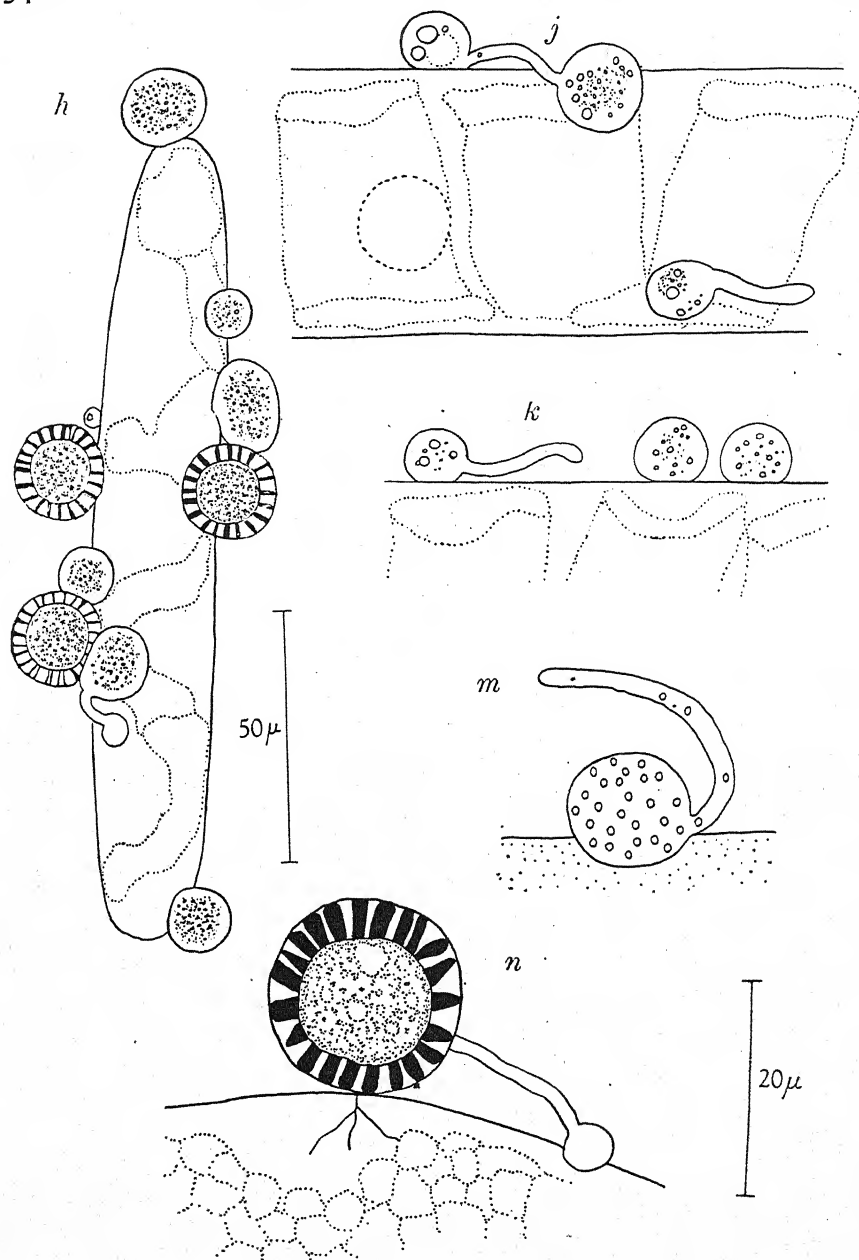
In *R. columnaris*, as in *Zygorhizidium*, certain aspects of its sexuality remain puzzling. Both Scherffel and Löwenthal describe dwarf thalli of *Z. Willei*, upon which a conjugation tube had formed, functioning as zoosporangia. In *Rhizophidium columnaris* one such specimen was observed (Text-fig. 4m). However, although the oil globules of the zoospores were delimited their actual liberation was not seen. This possibly gives further support to the suggestion, that the subsequent nature of the thallus produced from the zoospores in *Zygorhizidium* is determined by environmental conditions, and not due to inherent differences produced in the swimmers on germination of the resting spore.

***Rhizophidium columnaris* n.sp.**

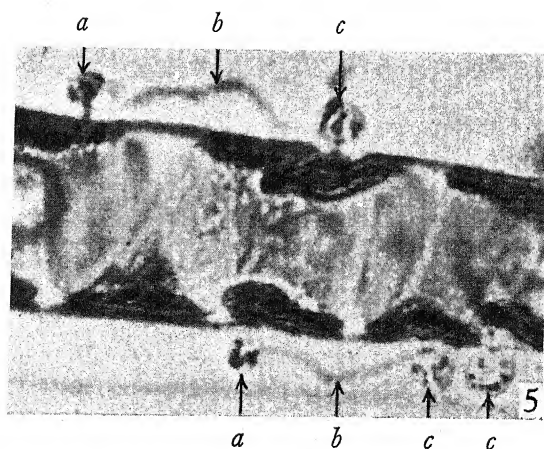
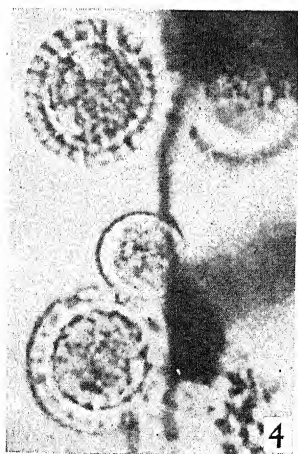
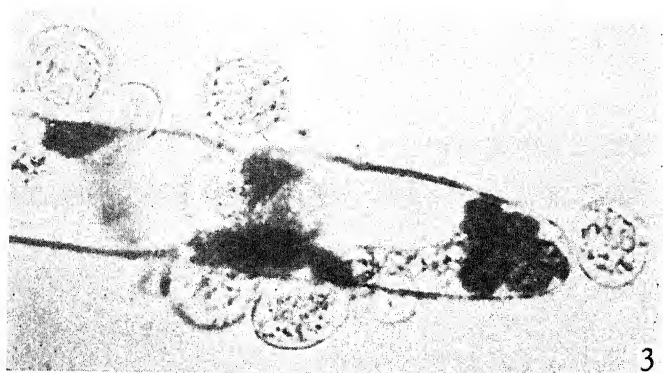
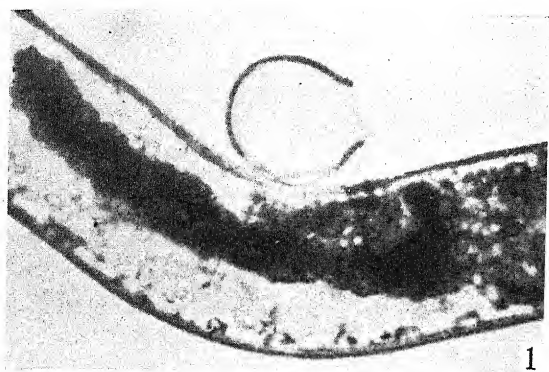
Thallus monocentric, epibiotic. Sporangium broadly ovoid, with its longer axis parallel to the host wall; wall smooth, colourless with a conical protuberance on its upper surface; large sporangia $25-63\mu$ broad \times $16-27\mu$ high; dwarf sporangia $8-15\mu$ broad \times $9-13\mu$ high; dehiscing by two broad, lateral, oppositely placed pores, very rarely one apical pore. Zoospores spherical, 2.6μ in diameter, uniflagellate, with a conspicuous anterior oil globule and a darker area laterally; emerging singly, movement



Text-fig. 3. *Rhizophidium columnaris* n.sp. a, encysted zoospores. b, young zoosporangium with centralized highly refractive contents; rhizoids not visible. c, young zoosporangium with well-developed rhizoids, the conical protuberance is visible on the upper surface. d, mature sporangium, oil globules of the zoospores delimited. e, dehiscence sporangium with zoospores. f, two empty sporangia and a mature dwarf sporangium. g, various stages in development of sporangia and resting spores. (All $\times 660$, except b, $\times 1400$.)



Text-fig. 4. *Rhizophidium columnaris* n.sp. *h*, stages in development of zoosporangia and resting spores. *j*, male thalli with developing conjugation tubes, one having fused with a female thallus. *k*, a male thallus, its conjugation tube approaching two female thalli. *m*, male thallus apparently functioning as a zoosporangium. *n*, mature resting spore showing highly refractive thickening bands of the wall, which are not as distinct from the rest of the wall as is suggested by the diagrammatic representation of the solid black against a white background. (All $\times 1400$, except *h*, $\times 660$.)



even gliding. Rhizoidal system branched arising from an indistinct main axis. Resting spore sexually formed, epibiotic, spherical, $10-20\mu$, wall up to 3μ thick, colourless, smooth, with columnar bands of refractive material; central contents granular, germination not observed. Male thallus epibiotic, spherical, connected to the female by a narrow cylindrical conjugation tube 2μ diameter and up to 38μ long.

Parasitic on *Spirotaenia condensata* Bréb., Clay Pond, Wray Castle, England.

Rhizophidium columnaris sp. nov.

Thallus monocentricus, epibioticus. Sporangium late ovoideum, decumbens, hyalinum, laeve, episporio una extremitate papillato; sporangia majora $25-63 \times 16-27\mu$, sporangia nana $8-15 \times 9-13\mu$, a duobus poris lateralibus oppositis vel rare a singulo poro apicale dehiscencia. Zoosporae sphaericae, 2.6μ diam., uniflagellatae, guttula anteriore distincta parteque obscuriore laterale praeditae, singulatim emergentes. Rhizoidea ramosa ex axe parum claro oriunda. Sporae perdurantes epibioticae, sphaericae, $10-20\mu$ diam., intus granulosae, episporio ad 3μ crasso, hyalino, laeve, interne lineis radiantibus refringentibus praedito; germinatio non visa. Thallus masculinus epibioticus, sphaericus, tubulo anguste 2μ diam. et ad 38μ longo cum femine conjunctus.

Hab. in *Spirotaenia condensata* Bréb. parasiticus, Clay Pond, Wray Castle, England.

My thanks are due to the Director of the Freshwater Biological Association for the use of a laboratory in which this work was done, to Miss E. M. Wakefield for the Latin diagnosis and especially to Prof. C. T. Ingold for his helpful criticism.

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EXPLANATION OF PLATE XI

Zygorhizidium Willei Löwenthal and *Rhizophidium columnaris* n.sp.

- Fig. 1. Empty sporangium of *Zygorhizidium Willei* with a broad lateral dehiscence pore. A slight curvature of the *Mougeotia* cell brought about by the fungus is visible. $\times 1030$.
- Fig. 2. *Zygorhizidium Willei*, male thallus with its conjugation tube. $\times 960$.
- Fig. 3. Part of a *Spirotaenia* cell showing zoosporangia and resting spores of *Rhizophidium columnaris*. $\times 820$.
- Fig. 4. A portion of fig. 3 more highly magnified showing two resting spores and a young zoosporangium. The columnar bands of thickening material are visible in the wall of the upper resting spore. $\times 1287$.
- Fig. 5. Part of a *Spirotaenia* cell with male and female thalli of *Rhizophidium columnaris*. (a) male thalli, (b) conjugation tube, (c) female thalli. $\times 1200$.

ANTI-FUNGAL SUBSTANCES FROM MOULDS

PART II. THE EFFECT OF PATULIN ON THE GROWTH OF
VARIOUS PLANT PARASITESBy GEORGE SMITH, *London School of Hygiene and Tropical Medicine*

Van Luijk (1938), in a paper dealing with antagonism between soil fungi, showed that, when *Penicillium expansum* (Link.) Thom. is grown on Knop's solution containing 4% sucrose, the culture filtrate has very marked powers of inhibiting the growth, *in vitro*, of *Pythium de Baryanum*. In addition, good results were obtained in suppressing the attack of the *Pythium* on lucerne seedlings by treating infected soil with the active filtrate. The substance responsible for the inhibitory effect was not, however, isolated and characterized.

Anslow, Raistrick and Smith (1943) found that patulin, previously isolated as a metabolic product of *Penicillium patulum* Bainier, is produced also, though in smaller yields, by various strains of *P. expansum* isolated from rotting fruits. It was demonstrated that patulin completely inhibits the growth of a number of species of *Pythium* at a concentration of 1:400,000, and that the fungistatic activity of culture filtrates from *Penicillium expansum* or *P. patulum* is in good agreement with their content of patulin, rendering it highly probable that van Luijk's active principle was indeed patulin.

It is now shown that patulin inhibits the growth of a number of other parasitic fungi, albeit at higher concentrations than that required to suppress the growth of species of *Pythium*. *Rhizoctonia Solani* Kühn is completely inhibited by patulin at a concentration of 1:10,000, *Sclerotium Rolfsii* Saccardo at 1:20,000, *Verticillium albo-atrum* Reinke & Berth. at 1:10,000, *Helminthosporium monoceras* Drechsler at 1:20,000, *H. gramineum* Rabenhorst at 1:20,000, *H. sativum* Pamm., King & Bakke at 1:5000, *Ceratostomella Pini* Münch. at 1:20,000, whilst *Botrytis cinerea* Pers. ex Fries is more resistant, being only partially inhibited at a concentration of 1:5000. It was also considered of interest to test the effect of patulin on *Trichoderma viride* Pers. ex Fries, a mould which itself produces anti-fungal substances (Weindling, 1932; Brian & McGowan, 1945). This species, like *Botrytis cinerea*, is only partially inhibited at a concentration of 1:5000. At lower concentrations the effect of patulin is stimulatory, giving more abundant fructification and enhanced production of pigment.

EXPERIMENTAL

Cultures. Typical strains of *Rhizoctonia Solani* (L.S.H.T.M. Catalogue no. BB192) and *Sclerotium Rolfsii* (BB191) were obtained from the National Collection of Type Cultures. Two strains of *Verticillium albo-atrum* were received from the East Malling Research Station, where they had been

isolated from diseased hops, one (X23) from a 'progressive' outbreak of the disease, the other (X24) from a typical 'fluctuating' infection. The culture of *Helminthosporium monoceras* (Ag117) was obtained in 1932 from C.B.S., Baarn. This species of the genus was included because it grows well, and regularly produces abundant conidia, on a variety of culture media. The strain of *H. gramineum* (Ag106) was obtained from Prof. F. T. Brooks in 1925 and does not produce conidia in culture. *H. sativum* (Ag105) was also obtained from Prof. Brooks, in 1932. Cultures on a variety of media produce conidia only tardily and sparingly. The strain of *Botrytis cinerea* (BB9A) was isolated in this laboratory from a wilted *Calceolaria* seedling. The culture of *Trichoderma viride* was isolated in 1927 from cotton yarn. It is a fast-growing strain and produces abundant yellow pigment on potato dextrose agar or wort-agar. *Ceratostomella Pini* was obtained from Dr W. P. K. Findlay.

METHOD OF TEST

The method described by van Luijk (1938), and used in this laboratory for the experiments with species of *Pythium*, is not suitable for testing organisms which grow only with difficulty when inoculated at the bottom of a tube of liquid medium. The method adopted was to make solutions of patulin in melted agar culture medium, pour into Petri dishes, and to sow each dish at a single central point with the fungus to be tested. In every series two or three dishes, containing the agar medium without patulin, were used as controls. The period of incubation varied with the fungus under test, but it was always at least as long as the time required for the control plates to be completely covered with typical growth.

As a preliminary, the action of patulin on *Pythium ultimum* was tested in this way, in order to find whether the two methods give comparable results.

The agar solutions of patulin were a series of twofold dilutions from 1 : 80,000 to 1 : 1,280,000. A number of solutions were made of patulin in Czapek-Dox solution, the concentrations being fifteen times the final concentrations required. These solutions were sterilized by steaming for fifteen minutes. Each final dilution was made by adding 1 ml. of the appropriate solution, with aseptic precautions, to a tube containing 14 ml. of melted Czapek agar at 45° C. The contents of the tube were well mixed and poured into a Petri dish. Dilutions were made in triplicate, each dish being inoculated with a fragment of mycelium from a young, vigorously growing culture of *Pythium ultimum*. The dishes were incubated at 24° C. for six days. Growth was completely inhibited at 1 : 320,000 and partially inhibited at 1 : 640,000. The activity of patulin, as shown by this method of test, is therefore of the same order as that shown by the earlier method, using liquid culture media.

RESULTS

Rhizoctonia Solani was tested in the same way as *Pythium*, but using a dilution series starting at 1 : 5000. The results were somewhat erratic. In one series there was complete suppression of growth on all plates at

1 : 10,000, two out of three plates at both 1 : 20,000 and 1 : 40,000 showed no growth after thirteen days' incubation, and there was definite retardation of growth at 1 : 80,000 and 1 : 160,000. In a second series there was again complete inhibition at 1 : 10,000, and on one plate at 1 : 20,000, but with little evidence of partial inhibition at higher dilutions.

Sclerotium Rolfsii. A series of tests using Czapek agar as the basal medium gave irregular results, but growth on the control plates, containing no patulin, was also erratic. The fungus grows much better on potato dextrose agar, and this medium was selected for a second series of tests. It was found, however, that solutions of patulin in potato extract turn brownish on heating. The pH of the extract is approximately 6, at which reaction patulin is not heat-stable. In order to avoid destruction of the substance during sterilization, the primary dilutions were made in potato extract containing dextrose, previously adjusted to pH 4.5 by addition of hydrochloric acid. In making the final dilutions in potato dextrose agar, the pH of the latter was not adjusted, since the temperature did not exceed 45° C. and, after addition of the patulin solution, the agar was maintained at this temperature for only a few seconds before being poured into a cold Petri dish. The dilution series used was 1 : 5000 to 1 : 80,000 in twofold steps. Plates were sown with fragments of mycelium from a young culture of *S. Rolfsii*, since the sclerotia are germinated only with difficulty in the laboratory.

There was complete inhibition at 1 : 20,000, with no sign of partial inhibition at higher dilutions. This clean line between complete inhibition at 1 : 20,000 and normal growth, with production of abundant sclerotia, at 1 : 40,000, is in sharp contrast to the reaction of *Verticillium albo-atrum*.

Verticillium albo-atrum was tested on Czapek agar, the dilution series being 1 : 5000, 1 : 10,000 and then twofold dilutions from 1 : 25,000 to 1 : 200,000. Both strains, X23 and X24, gave similar results, and with each there was very little variation between the three plates used for each dilution. Inhibition was complete at 1 : 10,000 and there was progressively more abundant growth from 1 : 25,000 to 1 : 200,000. Even at the highest dilution, however, there was appreciable retardation of growth, as compared with the controls.

Helminthosporium monoceras. Dilutions were made in Czapek agar, the series being 1 : 5000 to 1 : 160,000 in twofold steps. There was complete inhibition of growth at 1 : 10,000, and no visible growth at 1 : 20,000 after sixteen days' incubation. At the latter dilution microscopic examination of the plates after three days showed that a high percentage of the conidia used as inoculum had germinated. Further incubation, however, resulted in no further growth, the germ-tubes remaining short, unbranched, and abnormal in appearance. There was definite retardation of growth up to 1 : 80,000.

Helminthosporium gramineum. Potato dextrose agar was used for the tests, the primary dilutions being made with potato extract adjusted to pH 4.5, as for *Sclerotium Rolfsii*. The fungus was completely inhibited at a concentration of 1 : 20,000 and growth was retarded even at the highest dilution used, 1 : 160,000. In the early stages of growth all colonies showed the typical

purplish pigmentation, but after about ten days the plates at dilutions 1:40,000 and 1:80,000 showed only small central areas of pigment, whilst in the controls and the 1:160,000 plates pigmentation was general.

Helminthosporium sativum. This was tested on potato agar, at dilutions from 1:5000 to 1:160,000. Growth was completely inhibited at 1:5000 and there was partial inhibition at all higher dilutions. The colonies on different concentrations of patulin showed very little variation as regards texture and tendency to sporulation.

Ceratostomella Pini. This species also was tested on potato agar, as this has been found to be most favourable for production of perithecia. There was complete inhibition at 1:20,000 and retardation of growth up to 1:80,000. At 1:40,000 there was no growth after three days' incubation, although in this period the colonies on the control plates had reached 3.5 cm. in diameter, and even after seventeen days colonies remained thin and pale coloured, without any suggestion of perithecia.

Botrytis cinerea was tested in exactly the same way as *Verticillium albo-atrum*. At a concentration of patulin of 1:10,000 there was no apparent effect on the growth of the fungus, and at 1:5000 there was only slight retardation of growth.

Trichoderma viride. Czapek agar was used for dilutions from 1:5000 to 1:160,000. The control plates and those containing dilutions 1:10,000 upwards were completely covered by the mould in six days. At this stage the 1:5000 plates had colonies about 5 cm. in diameter, but after nine days even these plates were completely covered. The agar in the controls and the 1:5000 dilution plates remained colourless for several days and showed only a faint yellow colour after nine days' incubation. At all other dilutions the agar was definitely pigmented after three days and rapidly turned deep yellow. There is no doubt that, on Czapek agar, patulin in low concentrations stimulates pigment production.

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(Accepted for publication 20 January 1947)

THE MEASUREMENT OF POTATO BLIGHT

The method of measuring Potato Blight on the foliage proposed by a Sub-Committee of the Society's Plant Pathology Committee (Moore, 1943, p. 34) has now been tested over several seasons by a number of observers, and its practical usefulness has been satisfactorily established. Briefly, the method is to assess the percentage of leaf area destroyed by Blight by eye judgement based on the following Key, which is now presented in its finally revised form.

KEY

Percentage (D.M.)	Description
0	Not seen on field
0.1	Only a few plants affected here and there; up to one or two spots in 12 yd. radius
1	Up to ten spots per plant, or general light spotting
5	About fifty spots per plant or up to one leaflet in ten attacked
25	Nearly every leaflet with lesions, plants still retaining normal form: field may smell of blight, but looks green although every plant affected
50	Every plant affected and about one-half of leaf area destroyed by blight: field looks green flecked with brown
75	About three-quarters of leaf area destroyed by blight: field looks neither predominantly brown nor green. In some varieties the youngest leaves escape infection so that green is more conspicuous than in varieties like King Edward, which commonly shows severe shoot infection
95	Only a few leaves left green, but stems green
100	All leaves dead, stems dead or dying

In the earlier stages of a blight epidemic parts of the field sometimes show more advanced decay than the rest and this is often associated with the primary foci of the disease. Records may then be made as, say 1 + pf 25, where pf 25 means 25 % in the area of the primary foci.

Previous methods of blight measurement have adopted arbitrary scales of blight amounts. The present method has the advantage, that the figure given in each case, is a measure within fairly accurate limits of the actual percentage of leaf area destroyed. The error at the bottom of the scale will probably be less in magnitude than in the region of 50 and 75 %, but great accuracy is not really essential in this type of work, particularly when several observations are made at different dates through the season.

It should be emphasized that the method of Potato Blight measurement here outlined applies only to the disease on the *foliage*. For disease in the *tubers* a quite different method should be adopted. For most purposes the percentage of infected tubers is what is required and variations in the amount of disease on individual tubers are rarely of importance. Whether the tubers are in the soil or in the clamps the percentage of infection is easily obtained by the counting of samples, and if the samples are sufficient in number and taken at random, accurate estimations for the whole crop can be made.

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(Accepted for publication 15 March 1947)

SPRING FORAY, 1946

WHEATFEN BROAD, NORFOLK

A visit to Wheatfen Broad, Surlingham, Norfolk, from Friday to Monday, 24-27 May 1946, marked the occasion of the first post-war Spring Foray.

This visit was made possible by the kindness of Mr E. A. Ellis who, in addition to entertaining a party of members at his home at Wheatfen, placed his workroom and mycological library at the disposal of the visitors and gave unstintingly of his unrivalled knowledge of the locality. The Society is greatly indebted to Mr and Mrs Ellis for all they contributed to the success of the Foray.

Wheatfen Broad is an area of some 150 acres of Yare Valley swamp situated about seven miles from Norwich, to the north of Rockland Broad, and bounded on the east by the river Yare and on the slightly higher ground to the south-west by Surlingham Wood. The main estate consists of a series of 'marshes' intersected by several miles of shallow streams connecting a chain of small broads navigable to a punt. Tidal communication with the Yare is responsible for a regular circulation of water and the normal rise and fall of 8 in. in the water level. The characteristic features of the vegetation are reed swamp, *Glyceria* marsh, *Cladium* fen, and sallow-ash carr. This area, which is of great biological interest, and which will it is hoped be permanently preserved, has been studied intensively for the past ten years by a group of naturalists who have published their results in a series of papers in the *Transactions of the Norfolk and Norwich Naturalists Society* (see Ellis, xiii, 422-51, 1934, for a general account of the vegetation and xv, 191-219, 1941, for a list of micro-fungi by the same author).

Most of the twenty-five members and friends attending the Foray found themselves on unfamiliar ground and all found much of interest. The main objective was micro-fungi and the collections made represented more than a hundred species belonging to diverse groups. All the finds have been entered on the card index kept by Mr Ellis with a view to the eventual publication of a critical account of the fungi of Wheatfen so that here it has only been thought necessary to supplement comments on some of the more interesting records with a list of fungi found in association with certain marsh plants. Specimens of most of the finds have been deposited in the herbaria of Mr E. A. Ellis, the Imperial Mycological Institute, or the Royal Botanic Gardens, Kew.

Helicosporium phragmitis, which is not included in Wakefield and Bisby's list of British Hyphomycetes, was found in abundance on decaying stems of *Glyceria maxima*. These, according to A. E. Ellis, are its characteristic habitat in the Yare Valley but it has also been recorded on *Phragmites*, *Phalaris arundinacea*, and *Calamagrostis arundinacea*. *Clasterosporium caninum* on *Carex* attracted attention, for this fungus (originally described by Schweinitz in North America) appears to have been recorded for Europe only from

Norfolk. Among other Hyphomycetes, *Myrothecium inundatum* Fr. on an old sporophore of *Russula adusta* and *Pachybasium hamatum* (Bon.) Sacc. found growing with *Rhytisma acerinum* on sycamore leaves may be mentioned, while Prof. C. T. Ingold listed seven aquatic species on dead leaves in the tidal ditches. The resemblance of *Mitrula sclerotipus* growing from sclerotia on blackened remains of meadowsweet leaves to species placed in *Verpatina* Whetzel & Drayton, was noted and *Pachydiscia marchantiae* (Berk.) Boud. was found on the liverwort *Conocephalum*. The most noteworthy rust recorded was *Puccinia persistens* Plowr., forming abundant aecia on *Thalictrum flavum*. Larger basidiomycetes were infrequent but Miss Wakefield added six species of *Corticium*, including *C. niveocreteum* and *C. roseocreteum*, and nine of *Peniophora*, including *P. candida* Lyman (syn. *P. aegerita*) with the *Aegerita* stage, *P. leprosa*, and *P. pubera* to the list. There have been many records of entomogenous fungi from Wheatfen. During the Foray *Gibellula araneorum* (Schwein.) Syd. on spiders and *Isaria farinosa* (Holmsk.) Fr. on moth pupae were found.

Acknowledgement must be made to Mr M. B. Ellis, Dr R. W. G. Dennis, Mr S. J. Hughes, and Mr E. W. Mason for making critical determinations.

LIST OF FUNGI ASSOCIATED WITH CERTAIN MARSH PLANTS AT WHEATFEN BROAD

- Caltha palustris*. *Ramularia calthae* (Erikss.) Lindr.
Carex. *Marasmius menieri* (on *C. riparia*), *Arthrimum sporophlaeum* Fr.,
Clasterosporium caricinum Schw., *Gonatosporium puccinioides*
 (Fr.) Corda, *Volutella melaloma* Berk. & Br.
Cladium mariscus. *Pistillaria aculeata*, *Tetraploa aristata* Berk. & Br.
Equisetum palustre. *Stammaria persooni* (Fr.) Fuckel.
Filipendula ulmaria. *Mitrula sclerotipus* Boud.
Galium aparine. *Peronospora calotheca* de Bary.
Glyceria maxima. *Gibberella zeae* (Schw.) Petch, *Coprinus* (? *urticaecola*),
Dematium hispidulum Fr., *Helicosporium phragmitis* Höhncl.
Myosotis. *Synchytrium aureum* Schroet., *Erysiphe cichoracearum* DC.
Myrica gale. *Ovularia destructiva* (Phill. & Plowr.) Massee.
Peucedanum palustre. *Plasmopara nivea* (Ung.) Schroet. (also on *Aegopodium*
 and *Angelica*).
Phragmites communis. *Dasyclapha controversa* (Cooke) Rehm, *Pyrenopeziza*
arundinacea (DC.) Boud., *Lophodermium arundinaceum* (Fr.) Chev.,
Napicladium arundinaceum (Corda) Sacc.
Poa trivialis. *Passalora graminis* (Fuckel) Höhncl.
Salix. *Bertia moriformis* (Fr.) de Not., *Calyculosphaeria tristis* (Fuckel)
 Fitzpat., *Chaetosphaeria phaeostroma* (Dur. & Mont.) Fuckel,
Diaporthe eres Nits., *Eutypa flavovirens* (Fr.) Tul., *Gloniopsis*
levantica Rehm, *Hypoxylon rubiginosum* (Fr.) Fr., *Lophiostoma*
salicum (Fabr.) Sacc., *Nitschkia cupularis* (Fr.) Karst., *Rosellinia*
aquila (Fr.) de Not., *Pholiota erinacea* (Fr.) Quel., *Coniothecium*
amentacearum Corda.

REVIEW

Flax Diseases. By R. McKAY. (Flax Development Board, Ltd.; 2 Kildare Place, Dublin, 1947.) 55 pp., 52 figs. Price 5s.

At the beginning of the War flax jumped into prominence as an important crop: and in England and Wales alone the area devoted to it increased rapidly from about 4500 acres in 1939 to over 60,000 acres in 1944. Despite the wise precaution of ensuring that all flax seed was suitably disinfected with Nomersan before sowing, some anxiety was not unnaturally felt about the possible development and spread of disease in the crop, and this in turn revealed a gap in plant disease literature, for no general account of flax diseases was available to farmer or adviser. This gap has now been filled very adequately by Prof. McKay's informative booklet, which provides all those interested in flax cultivation with a concise account of its pathology and a means whereby all the significant diseases and pests of the crop can be recognized in the field. The text is a happy blend which satisfies the plant pathologist without diminishing the value of the bulletin as a guide for the interested factory fieldsman and grower. Well-selected references are given after the description of each disease, though a few recent ones that might be expected in a publication appearing in 1947 are missing. There is a glossary of technical terms, and indexes to common and scientific names as well as to authors. The bulletin is very attractively designed and profusely illustrated: it would be interesting, however, to see the effect of applying colour work to this rather difficult photographic subject. Mycologists may well be puzzled by the invariable use of brackets for the authorities of the fungus names.

W. C. MOORE

EDITORIAL NOTE

It is intended, as soon as circumstances allow, to issue the Proceedings of the Jubilee Celebrations of the British Mycological Society as Volume XXX of the *Transactions*: this volume will be sent to all who were members on 30 June 1947. In accordance with this intention, the present volume is numbered XXXI.

REVISED LIST OF BRITISH
AGARICS AND BOLETI

BY A. A. PEARSON AND R. W. G. DENNIS

The present list of species will, we hope, be of service to students. It can be used both as a check list and as an indication of the modern aspects and tendencies in the taxonomy of this group of fungi.

Our fungus books are cluttered with names that have little or no meaning, and it is time such names were withdrawn. This was the first purpose which induced us to undertake the task of preparing a list of species which we believe to be distinct and to have been correctly reported as British.

The specific epithets which we have excluded are:

- (1) Synonyms.
- (2) Names attached to inadequate descriptions.
- (3) Species unlikely to occur in Britain.
- (4) Species which have been interpreted in more than one sense.
- (5) Errors due to carelessness.
- (6) Alien species included in existing floras on account of casual occurrences among hothouse plants.

The sifting was no easy task, and the result will not please everybody. Objections will come from two sides. We shall be told that we have been too drastic. That will be put right if and when species wrongly excluded are rediscovered and more fully described. Some will think we have left in species that are not really known to any living mycologist. That is true, but species may be so rare that only by very fortunate circumstances are they likely to be met with by a mycologist competent to name them. If they have points of distinction that make it likely that they are authentic species, different from any familiar to us, we have preferred not to discard them—at least for a few years more.

It does not follow then that all the specific names left in the list are guaranteed to be of permanent value. We are all too familiar with the light-hearted way in which names were given to fungi in the old days and the many pitfalls that beset mycologists when dealing with critical groups. All we can claim is that we have done our best to produce a list of species which actually do exist in Britain.

The total number of the Agaricales left in our list is 1234, contrasted with about 1870 species contained in the latest authoritative work, Carleton Rea's *British Basidiomycetae*, and those subsequently recorded. The Boletales number 47 compared with 70. This does not take into account the varieties which we have dealt with somewhat relentlessly. About one-third of the names then have been excluded, and the reasons will be found in the explanatory notes at the end of each genus.

There are, however, many more agarics that await determination. As we get to know the fungi more, the twofold process of 'lumping' and 'splitting' must go on. The new methods of diagnosis, which lay greater stress on microscopic features and give some diagnostic value to chemical reactions, will certainly lead to the multiplicity of names. All we can hope for is that the tendency to split into innumerable 'Jordanian' species will not be carried to excess.

Our second object was to bring forward a transitional grouping which would bear some relation to modern tendencies in taxonomy and at the same time not interfere too violently with the Friesian framework which still seems the most practical. This has already been done in a narrower field with the publication by the Essex Field Club of the *List of the Fungi of Epping Forest*, by A. A. Pearson (1938). We have adhered to the general classification based on the colour of the spores which still seems as good as any other, and is the most convenient for the display of specimens at fungus forays. In recent years, however, many new genera have been introduced, and we have indicated these in our sectional headings by *enclosing the new generic epithets in brackets*. The new genera may thus become familiar to those who use this list, and later they can be adopted if thought worthy of generic rank. Much as we appreciate the activities of the modern mycologists who have been carving so many new genera out of the old, we think that many of these are based on such small differences that they are scarcely worthy of more than sectional status.

The works consulted are too numerous to mention. We have been fortunate in having open to us in the Herbarium of the Royal Botanic Gardens, Kew, the full range of books on systematic mycology. In the citation of authors we can hardly hope to have avoided occasional errors, and there are doubtless many specific names which will require changing when all the sifting has been done to bring them into line with the International Rules of Botanical Nomenclature. In a few cases, to avoid confusion, we have preferred not to disturb well-established epithets when there was some slight doubt as to the claims of priority. On the other hand, many familiar names have to go. These are mostly those which must be replaced by the epithets used by Fries in the *Systema Mycologicum* (1821), which, according to the International Rules, is the starting-point for the groups we have dealt with. The specific epithets in this work are valid when we clearly know what species he was referring to, even though in later books, he discarded them—as he often did.

In our author citations, in most cases we have followed the usual practice in quoting Fries as the generic authority in instances in which he actually referred to sections or subgenera of Agarics. This does not comply strictly with the International Rules of Nomenclature, but we have felt unable to spare the time necessary for the exhaustive search of the literature required to establish who first raised the subgenus to full generic rank in the case of each separate species. This sterile occupation appears particularly purposeless, as many names are likely to be changed afresh as soon as some of the sections of Friesian genera are accorded in Britain the generic status they have already attained elsewhere.

Neither have we followed exactly the Recommendation xxxii of the International Rules, but have continued what has hitherto been the common practice of citing the original author of a species in curved brackets instead of in square brackets or by using *ex* before the author whose description is accepted as defining the species. Some authors appear to have misunderstood this recommendation and place *ex* before the earlier author—Fr. *ex* Bull.—instead of before the later author—Bull. *ex* Fr.

A last note about the classification. It is only tentative and many of the sections are somewhat artificial. Some genera would be excluded from the Agaricales if due weight were given to the histological data accumulated in recent years. Doubtless there will be many changes in the taxonomy of this vast group of the fungi. With our present limited knowledge we have not felt called upon to do more than bring forward a transitional arrangement which, while not satisfying the more learned, will, we hope, be of service to mycologists who want an easily accessible outline classification of the British species. Some such critical revision of the published names is, in any case, necessary before a revision of the British Agaric Flora can be contemplated.

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AGARICALES

Gen. AMANITA (Pers.) Fr.

Liberæ

- Amanita phalloides* (Vaill.) Fr.
 verna (Bull.) Fr.
 virosa Fr.

Semi-limbatae Gilbert

- Amanita porphyria* (A. & S.) Fr.
 citrina (Schaeff.) Roques
 var. *alba* Price
 gemmata (Fr.) Gillet
 Eliae Quél.

Floccosae Gilbert

- Amanita muscaria* (Linn.) Fr.
 var. *formosa* Fr.

- Amanita muscaria* var. *regalis* Fr.
 solitaria (Bull.) Fr.
 pantherina (DC.) Fr.
 f. *robusta* Pearson
 excelsa Fr.
 rubescens (Pers.) Fr.
 var. *annulo-sulphurea* Gillet
 aspera (Fr.) Quél.

(*Lepidella* Gilbert)

- Amanita Vittadini* (Moretti) Vitt.
 echinocephala Vitt.

Gen. AMANITOPSIS Roze

- | | |
|--|--|
| <i>Amanitopsis vaginata</i> (Bull.) Roze
<i>fulva</i> (Grev.) Rea | <i>Amanitopsis nivalis</i> (Schaeff.) W.G.Sm.
<i>inaurata</i> (Secr.) Boud. |
|--|--|

NOTES

- Amanita aculeata* Quél.—probably *A. echinocephala*.
 cariosa Fr. = *A. excelsa*.
 Emilii Riel.—a form of *A. muscaria*.
 lutea Otth.—doubtful species.
 mappa (Batsch.) Fr. *Epicr.* 1836 = *A. citrina* (Schaeff.) Roques, 1832.
 nitida Fr.—probably *A. solitaria*.
 ovoidea (Bull.) Fr.—a Mediterranean species reported as far north as Paris. There are two British records, neither very convincing.
 recutita Fr. = *A. porphyria*.
 spissa Fr. *Epicr.* 1836 = *A. excelsa* Fr. *Syst.* 1821. There is little doubt that these two epithets represent the same species, *A. excelsa* being the form with the stem starting from deep in the ground, which causes it to have a less characteristic obconic shape at the base.
 strobiliformis Vitt. = *A. solitaria*.
 verna (Lam., Bull., Pers.) Fr. is rather a problem. Fries in *Syst. Myc.* states '*stipes...laceratus*', which points to what later he called *virosa*. However, he cites Bulliard, tab. 108, in *Herbier de la France*, where the stem is perfectly smooth apart from the pendulous ring. To avoid

confusion it is better to use *virosa* for the *Amanita* with rough squamulose stem. Until recent years *A. verna* (Bull.) was looked upon as a variety of *A. phalloides*, but is now accepted as a separate species.

Amanita Vittadinii (Moretto) Vitt.—left in, but doubtful if found in northern Europe. Cke. *Ill.*

33 (36) was copied from Krombholz.

Amanitopsis strangulata (Fr.) Roze = *A. inaurata*.

adnata (W.G.Sm.) Sacc. = *Amanita gemmata*.

Gen. LEPIOTA Fr.

(*Limacella* Earle em. Maire)

Lepiota illinita Fr.

guttata (Pers.) Fr.

glioderma Fr.

arida Fr.

delicata Fr.

(*Lepiotella* Gilbert)

Lepiota irrorata Quél.

medullata Fr.

Procerae Fr.

Lepiota procera (Scop.) Fr.

mastoidea Fr.

excoriata (Schaeff.) Fr.

gracilentia (Krombh.) Fr.

rhacodes (Vitt.) Fr.

var. *puellaris* Fr.

nympharum Kalch.

permixta Barla

Olivieri Barla

Badhamii B. & Br.

naucina Fr.

holosericea Fr.

Echinatae Fayod

Lepiota acutesquamosa (Weinm.) Fr.

echinella Quél.

hispida (Lasch) Fr.

Granulosae Fr.

(*Cystoderma* Fayod)

Lepiota granulosa (Batsch) Fr. sensu Lange

cinnabarina (A. & S.) Fr.

amianthina (Scop.) Fr.

carcharias (Pers.) Fr.

haematites (B. & Br.) comb. nov.

lilacea Bres.

nigromarginata Mass.

Micaceae Lange

Lepiota Bucknallii B. & Br.

sistrata Fr.

rosea Rea

Pilosellae Kühner

Lepiota Georginae W.G.Sm.

Anomalae Lange

Lepiota Eyrei (Mass.) Lange

haematosperma (Bull.) Boud.

Fusisporae Lange

Lepiota clypeolaria (Bull.) Fr.

laevigata Lange

alba (Bres.) Sacc.

erminea Fr.

Stenosporae Lange

Lepiota fulvella Rea

castanea Quél.

cristata (A. & S.) Fr.

pseudo-felina Lange

Grangei (Eyre) Lange

Ovisporae Lange

Lepiota constricta (Fr.) Quél.

meleagris (Sow.) Fr.

brunneo-incarnata Chod. & Mart.

helveola Bres.

fusco-vinacea Möller & Lange

citrophylla B. & Br.

felina (Pers.) Fr.

gracilis (Quél.) Rea

scobinella (Fr.) Quél. & Bat.

clypeolarioides Rea

serena Fr. sensu Kühner

parvannulata (Lasch) Fr.

Leucobolbitius Lange

Lepiota cepaestipes (Sow.) Fr.

lutea (Bolt.) Quél.

Brebissonii Godey

Gen. *ARMILLARIA* Fr.

(Armiliariella Karst.)

(Mucidula Pat.)

Armillaria mellea (Vahl.) Fr.*Armillaria mucida* (Schrad.) Fr.

NOTES

Lepiota amianthina (Scop.) Fr.—it would perhaps be more correct to name this species *L. granulosa*, since Fries used it in *Syst. Myc.* citing *L. amianthina* Scop. as synonym; but he also cited Bulliard's two plates of *Agaricus ochraceus* which appear to represent both species in question.

arida Fr.—left in, but the record requires confirmation.

atro-crocea W.G.Sm.—from Somerset (1903), description inadequate.

biornata B. & Br.—alien, only in hothouses.

cepaestipes var. *cretacea* Grev. = *L. Brebissonii*.

constricta (Fr.) Quél.—probably the same as *Tricholoma leucocephalum* but left as separate species for the present. If proved to be identical, the former epithet would be valid.

emplastrum Cke. & Mass. = *L. rhacodes*.

Friesii (Lasch) Fr. = *L. acutesquamosa*.

ianthina Cke.—an alien; in stove at Kew.

lenticularis Lasch = *L. guttata*.

martialis, Cke. & Mass.—alien, on palm stem.

mesomorpha (Bull.) Fr.—doubtful record.

micropholis B. & Br.—a Ceylon species, in greenhouse.

Pauletii Fr.—doubtful species.

polysticta Berk. (1860)—both description and figure in Cke. *Ill.* 41 (30) suggest *L. granulosa*.

pratensis (Fr.) Rea = *L. clypeolaria*.

prominens Fr. = *L. mastoidea*.

pseudo-licmophora Rea = *L. lutea*.

rosea Rea—left in list, but Lange thinks it to be *L. rufescens* B. & Br.

seminuda (Lasch) Fr. = *L. sistrata*.

submarasmoides Speg.—the original diagnosis refers to a minute agaric found in the Argentine which hardly corresponds to the species described by Rea.

Glaucospora Rea—established to include species of *Lepiota* with spores tinted blue or green, a character which hardly calls for a new genus. *Glaucospora Eyrei* has been listed as *Lepiota Eyrei*.

Schulzeria Bres.—this genus has also been withdrawn. The two species in the British list both suggest the presence of a veil though not forming a ring on the stem; but this happens with many species of *Lepiota*. *Schulzeria Grangei* Eyre takes its place in the group of *Lepiota* with projectile-shaped spurred spores, and *Schulzeria lycoperdoides* Cke. & Mass. is doubtful.

Armillaria Fr.—the heterogeneous collection of agarics attached to this genus had only one feature in common: the presence of a ring. Fries himself from the *Syst. Myc.* onwards divided up his section *Armillaria* into groups which were respectively akin to *Tricholoma*, *Clitocybe*, *Pleurotus* and *Collybia*. In the present list we have followed the example of modern authors and transferred the appropriate species to these different genera. Only two species both common, are left to represent *Armillaria*. Even these have been abandoned by some authors for other genera.

Armillaria bulbigera (A. & S.) Fr. = *Tricholoma bulbigera*.

caligata (Viv.) Fr. = *Tricholoma caligata*.

citri (Inzenga) Fr.—a form of *A. mellea*.

colossa (Fr.) Boud. = *Tricholoma colossum*.

constricta Fr. = *Lepiota constricta*.

delicata (Fr.) Boud. = *Lepiota delicata*.

denigrata Fr.—probably *Pholiota erebia*.

focalis Fr. = *Tricholoma robustum*.

haematites B. & Br. = *Lepiota haematites*.

Jasonis Cke. & Mass.—Cooke's figure, Pl. 1113 (955), shows a robust form of *Lepiota amianthina*.

Armillaria mellea (Vahl) Fr.—this polymorphous species has a large number of varieties, none of which is included in this list. The var. *tabescens* is accepted as a separate species and will be found under *Clitocybe*. *C. ectypa* is also related but the British record is doubtful.
robusta (A. & S.) Fr. = *Tricholoma robustum*.
ramentacea (Bull.) Fr. = *Tricholoma ramentacea*.
rufa (Batt.) Quél.—Cooke's figure 51 (33) represents *Tricholoma robustum*, and there has been no other collection published.
subcava (Schum.) Fr.—doubtful; Cooke's figure 57 (47) is *Lepiota Brebissonii*.

Gen. TRICHOLOMA Fr.

Albida

Tricholoma gambosum Fr.
album (Schaeff.) Fr.
lascivum (Fr.) Gillet
spermaticum Fr.
resplendens Fr.
columbetta Fr.
sulphurescens Bres.
inamoenum Fr.
leucocephalum Fr.
 (See also *Clitocybe connata*)

Fumosa

Tricholoma aggregatum (Schaeff.) Secr.
pergamenum (Cke.) comb. nov.
cartilagineum Fr. non Bull.
cinerascens (Bull.) Fr.
loricatum Fr.
immundum Berk.
semitale (Fr.) Ricken
infumatum (Bres.) comb. nov.
leucophaeatum Karst.

Brunneola

(a) *Limacina* Fr.

Tricholoma albo-brunneum (Pers.) Fr.
ustale Fr.
pessundatum Fr.
fulvum Fr.
acerbum (Bull.) Fr.

(b) *Flocculosa* Fr.

Tricholoma imbricatum Fr.
vaccinum (Pers.) Fr.
psammopus (Kalch.) Fr.
macrorrhizum (Lasch) Fr.

(c) (*Armillaria* Fr.)

Tricholoma robustum (A. & S.) Fr.
caligatum (Viv.) Fr.
colossus Fr.
aurantium (Schaeff.) Fr.

Variecolorata

Tricholoma flavo-virens Fr.
 (= *equestre* (Linn.) Fr.)
fucatum (Fr.) Gillet
sejunctum (Sow.) Fr.
 var. *corypheum* (Fr.) comb. nov.
portentosum Fr.
sulphureum (Bull.) Fr.
 var. *bufonium* (Pers.) Fr.
saponaceum Fr.
 var. *squamosum* Cke.
rutilans (Schaeff.) Fr.
 var. *variegatum* (Scop.) Fr.
decorum Fr.

(*Armillaria* Fr., *Cortinellus* Roze and
Leucocortinarius Lange)
bulbigerum (A. & S.) Fr.

Myomycetes

Tricholoma terreum Fr.
sculpturatum Fr.
Inocybeoides Pearson
triste (Scop.) Fr.
atro-squamosum (Chév.) Sacc.
 var. *squarrulosum* Bres.
horribile Rea
oirubens Quél.
 var. *guttatum* (Schaeff.) comb. nov.
inodermeum Fr.
virgatum Fr.
gausapatum Fr.

(*Armillaria* Fr.)

Tricholoma ramentaceum (Bull.) Quél.

Graciles

Tricholoma carneum (Bull.) Fr.
onychium Fr.
ionides (Bull.) Fr.
 var. *obscurissima* Pearson
 var. *persicolor* (Fr.) Bres.

Dermoloma Lange

Tricholoma atrocinerum (Pers.) Fr.
cuneifolium Fr.

(*Melanoleuca* Pat.)

Tricholoma melaleucum (Pers.) Fr.
 var. *polioleucum* (Fr.) Gillet
 var. *adstringens* (Pers.) Quél.
grammopodium (Bull.) Fr.
cognatum Fr.
evenosum Sacc.
turritum Fr.

(*Rhodopaxillus* Maire)

Tricholoma nudum Fr.
 var. *lilaceum* (Quél.) Kühner & Maire
glaucochanum Bres.
sordidum Fr.
personatum Fr.
panacolum Fr.
truncatum (Schaeff.) Quél.
irinum Fr.
 (See also *Clitocybe*)

(*Rhodocybe* Maire)

Tricholoma caelatum Fr.

NOTES

Tricholoma albellum Fr. = *gambosum* Fr.
amplum (Pers.) Rea = *T. aggregatum*.
amarum (A. & S.) Quél. = *Clitocybe amara* Fr.
amethystinum (Scop.) Fr. = *T. personatum* Fr.
amicum Fr.—doubtful species.
arcuatum (Bull.) Quél. = *T. cognatum* Fr.
argyraceum (Bull.) Fr. = *T. sculpturatum* Fr.
boreale Fr. = *T. irinum* Fr.
brevipes (Bull.) Fr. = *T. melaleucum* form.
centurio Kalch.—doubtful.
cerinum (Pers.) Fr.—doubtful record.
chrysites (Jungh.) Gillet = *T. sculpturatum* Fr.
circumtectum Cke. ? = *T. atro-squamosum*.
civile Fr. = *Clitocybe amara* Fr.
cnista Fr. = *sec.* Lange form of *saponaceum*, but most authors attach it to *Melanoleuca* group.
compactum Fr.—added to British list by Masee in 1911 without substantiating data.
duracinum Cke. = *cinerascens*.
elytroides (Scop.) Fr.—doubtful.
equestre (Linn.) Fr. = *flavo-virens* as in *Syst. Myc.*, though Fries abandoned this later for the Linnean name.
excisum Fr. = *T. melaleucum*.
fallax Peck.—doubtful record.
flavobrunneum Fr. = *T. fulvum* (DC.) Fr.
focale Fr.—record uncertain. Cke. Ill. 49 (245) suggests a form of *T. aurantium*.
focale var. *Goliath* Fr.—also uncertain.
fulvellum Fr. = *T. fulvum*.
Georgii (Clus) Fr. = *T. gambosum*.
hordum Fr.—doubtful species.
horribile Rea—left in, but doubtful if other than a form of *orirubens*.
humile (Pers.) Fr. = *T. melaleucum*.
impolitum (Lasch) Fr. = *T. psammopus*.
interveniens Karst.—no British record.
irregularis Karst. = *albobrunneum*.
laxivium Fr. ? = *T. melaleucum*.
luridum (Schaeff.) Fr. = *T. saponaceum*.
luteocitrinum Rea = *Hygrophorus lucorum* Kalch.
militare (Lasch) Fr.—identity doubtful.
murinaeum (Bull.) Fr. = *T. virgatum*.
myomyces Fr.—this epithet was used in *Syst. Myc.* for the whole group of *Tricholoma* of which *T. terreum* is the commonest species. If the rules are strictly followed *T. myomyces* should perhaps replace *terreum*. We prefer to use the epithet as a Section heading.
nictitans Fr. = *T. fulvum*.

Tricholoma opicum Fr.—identity uncertain.

opiparum (Fr.) Quél. = *Hygrophorus nemoreus*.

oreinum Fr. = *T. melaleucum*.

paedidum Fr. = *T. melaleucum*.

patulum Fr. = *T. melaleucum*.

pes-caprae Fr. = *T. cinerascens*.

phaeopodium (Bull.) Quél. = *T. melaleucum*.

porphyroleucum (Bull.) Fr. = *T. melaleucum* or *T. ionides* var. *obscurissima*.

putidum Fr. = *Collybia putida* (Fr.) Kühner & Maire.

quinquepartitum Fr.—uncertain species; probably *T. sejunctum*.

saevum Gillet = *T. personatum* Fr.

Schumacheri Fr.—identity doubtful.

stans Fr. = *T. pessundatum*.

subpulverulentum (Pers.) Fr. = *T. melaleucum*.

sudum Fr.—doubtful record.

tenuiceps Cke. & Mass. = *Collybia platyphylla*.

tumidum (Pers.) Fr.—doubtful record.

turritum Fr.—probably *T. melaleucum*.

unguentatum Fr.—identity uncertain.

Gen. CLITOCYBE Fr.

(*Aspropaxillus* Kühner & Maire)

Clitocybe gigantea (Sow.) Fr.

(*Leucopaxillus* Boursier)

Clitocybe amara Fr.

paradoxa Const. & Duf.

(*Cantharellula* Singer)

Clitocybe umbonata Fr.

cyathiformis (Bull.) Fr.

obbata Fr.

(*Lepista* W. G. Sm. em. Pat.)

Clitocybe flaccida (Sow.) Fr.

gilva (Pers.) Fr.

(*Rhodopaxillus* Maire)

Clitocybe popinalis (Fr.) Bres.

f. *senilis* Fr.

mundula (Lasch) comb. nov.

(*Hygrophoropsis* (Schroet.) Maire)

Clitocybe aurantiaca (Wulf.) Studer

var. *albida* Gillet

var. *nigripes* Pers.

albida (Fr.) Konrad

Carnosae Lange

Clitocybe geotropa (Bull.) Fr.

var. *maxima* (Fr.) Nüesch

nebularis (Batsch) Fr.

Clitocybe clavipes (Pers.) Fr.

obscurata Cke.

inornata (Sow.) Fr.

var. *exilis* Pearson

odora (Bull.) Fr.

var. *Trogii* (Fr.) Maire

pseudoconglobata Rea

tabescens (Scop.) Bres.

Sub-carnosae

Clitocybe infundibuliformis (Schaeff.) Fr.

var. *catinus* Fr.

incilis Fr.

sinopica Fr.

paropsis Fr.

vermicularis Fr.

parilis Fr.

trullaeformis Fr.

hirneola Fr.

Albatae

Clitocybe cerussata Fr.

phyllophila Fr.

monstrosa (Sow.) Gillet

pithyophila Fr.

rivulosa (Pers.) Fr.

dealbata (Sow.) Fr.

candicans (Pers.) Fr.

ericetorum (Bull.) Fr.

connata (Schum.) Fr.

tuba Fr.

Hygrophanae, Decurrentes

Clitocybe vibecina Fr.
expallens (Pers.) Fr.
concava (Scop.) Fr.
brumalis Fr.
fritilliformis (Lasch) Fr.
angustissima (Lasch) Fr.
incana Quél.

Sub-decurrentes

Clitocybe diatreta Fr.
ditopus Fr.
metachroa Fr.
fragrans (Sow.) Fr.
obsoleta (Batsch) Fr.
albocinerea Rea

Gen. *LACCARIA* B. & Br.

Laccaria laccata (Scop.) Cke.
proxima Boud.
amethystina (Vaill.) Cke.

Laccaria tortilis (Bolt.) Cke.
nana Masee
bella (Pers.) Cke.

NOTES

- Clitocybe aggregata* (Schaeff.) Fr. = *Tricholoma aggregata*.
amarilla (Pers.) Fr.—? form of *C. (Rhodopaxillus) popinalis*.
cartilaginea (Bull. non Fr.) Bres. = *Tricholoma loricatum*.
comitalis (Pers.) Fr.—identity doubtful.
conglobata (Vitt.) Bres. = *Tricholoma aggregatum*.
cryptarum (Letell.) B. & Br.—identity uncertain.
curtipes Fr.—may be *Tricholoma panaeolum*.
cyanophaea Fr.—probably *Tricholoma nudum*.
decastes Fr.—in *Syst. Myc.* appears to be the same as *Tricholoma cinerascens* Bull., and in later works of Fries hardly distinct from *Tricholoma aggregatum*.
ectypa Fr.—British records are doubtful. Cke. *Ill.* 177 (126) is *C. cyathiformis*.
elixa (Sow.) Berk. = *C. inornata* or *C. Alexandrii*.
gallinacea (Scop.) Fr. = *Omphalia hydrogramma*.
gangraenosa Fr. = *Tricholoma leucophaeatum* Karst. The epithet *gangraenosa* would have priority but its identity is in doubt.
geotropa (Bull.) Fr. *Epicr.*—we have hesitated whether to use the epithet *gibba* Fr. for this species. It is the *Agaricus gibbus* (Pers.) Fr. var. *major* Fr. *Syst. Myc.*, but the type of *gibbus* is uncertain.
hyphnorum (Brond.) Rea—suggests *Hygrophorus lucorum*.
inversa (Scop.) Fr. = *C. flaccida* (Sow.) Fr.
luscina Fr.—? *Tricholoma panaeolum*.
monstrosa (Sow.) Gill.—left in list but suggests *C. cerussata*.
obbata Cke.—remains in list only on authority of Cke. *Ill.* 168 (230).
occulta Cke.—a *Tricholoma* of the *Myomyces* group. May be a good species but requires clearer definition.
opaca (With.) Fr. = *C. cerussata*.
orbiformis Fr.—not clearly defined.
pausiaca Fr.—doubtful.
pergamena Cke. = *Tricholoma pergamenum*. Suggests *T. aggregatum* but for the elliptical spores.
polia Fr.—? *C. inornata*.
pruinosa (Lasch) Fr.—doubtful record.
senilis Fr. = form of *C. popinalis*.
socialis Fr.—description inadequate but Cke. *Ill.* 132 (134) looks distinctive.
splendens (Pers.) Fr. = *C. gilva* Fr.
suaveolens (Schum.) Fr.—though this may be a good species, it requires clearer definition before it can be considered distinct from *C. fragrans*.
subalutacea (Batsch) Fr.—doubtful record.
subdecastes Cke. & Mass. = *Tricholoma cinerascens*.
subinvoluta W. G. Sm. = *C. geotropa*.
tornata Fr. = *C. cerussata*.
Trogii Fr. = var. of *C. odora*.
tumulosa (Kalch.) Fr. = *Tricholoma aggregatum*.

Clitocybe venustissima Fr.—? *Omphalia demissa*.

vernica Fr.—probably *C. flaccida*.

viridis (With.) Fr.=*C. odora*.

zygophylla Cke. & Mass.=*C. inornata*.

Laccaria bella (Pers.) B. & Br.—left in list though doubtful, but the foetid smell would distinguish it.

nana Massee—retained in list on account of the large spore 15–16 μ , but requires confirmation.

Gen. MYCENA Fr.

Calodontes

Mycena pelianthina Fr.

avenacea Fr.

atro-marginata Fr.

rubro-marginata Fr.

elegans Fr.

rosella Fr.

pterigena Fr.

atro-virens Rea

Seynii Quél.

(See also *haematopus*)

Lactipedes Fr.

Mycena galopus (Pers.) Fr.

var. *alba* Fl. Dan.

var. *nigra* Fl. Dan.

sanguinolenta (A. & S.) Fr.

haematopus (Pers.) Fr.

var. *marginata* Lange

crocata (Schrad.) Fr.

Basipedes Fr.

Mycena stylobates (Pers.) Fr.

bulbosa Cejp

tenerima Berk.

(See also *pterigena*)

Pruinosae

Mycena amicta Fr.

Adonideae Fr.

Mycena pura (Pers.) Fr.

var. *rosea* Schum.

var. *multicolor* Bres.

var. *alba* Gillet

pseudo-pura Cke.

zephyrus Fr.

flavipes Quél.

Adonis (Bull.) Fr.

acicula (Schaeff.) Fr.

atrocyanea (Batsch) Fr.

urania Fr.

Glutinipedes Fr.

Mycena epipterygia (Scop.) Fr.

viscosa (Secr.) Maire

epipterygiodes Pearson

Mycena pelliculosa Fr.

vulgaris (Pers.) Fr.

Roridae Kühner

Mycena rorida (Scop.) Fr.

Alcalinae Konr. & Maubl.

Mycena alcalina Fr.

ammoniaca Fr.

aetites Fr.

(See also *rubromarginata*)

Rigidipedes

Mycena polygramma (Bull.) Fr.

vitilis Fr. non Kühner

erubescens v. Höhnelt

subalpina v. Höhnelt

galericulata (Scop.) Fr.

inclinata Fr.

Albidulae

Mycena lactea (Pers.) Fr.

gypsea Fr.

speirea Fr.

hiemalis (Osbeck) Fr.

flavo-alba Fr.

trachyspora Rea

quisquiliaris (Joss.) Kühner

Granulatae Lange

Mycena metata Fr.

chlorantha Fr.

var. *pallida* Pearson

arcangeliana Bres. var.

Oortiana Kühner

filopes (Bull.) Fr. non Kühner

cinerella Karst.

uracea Pearson

fagietorum Fr.

corticola (Pers.) Fr.

mirata Peck sensu Smith

capillaris (Schum.) Fr.

debilis Fr.

mucor (Batsch) Fr.

polyadelpha (Lasch ex Fr.) Kühner

osmundicola Lange

(*Mycenella* Lange)

Mycena lasiosperma Bres.

NOTES

- Mycena atro-alba* (Bolt.) Fr.—identity not clear.
aetites Fr.—placed next to *M. ammoniaca* to which it approximates, but has no smell.
aurantio-marginata Fr. = *M. elegans*.
balanina Berk. = *Marasmius cohaerens*.
Berkeleyi Mass.—based on Cooke's figure 224 (148) of *M. excisa* which represents a dark-coloured *M. galericulata*; but if Masee's spores $5 \times 3\frac{1}{2} \mu$ are correct, it is certainly distinct.
carneo-sanguinea Rea—cystidia not given but almost certainly a form of *M. pelianthina*.
chelidonia Fr.—doubtful; may be a form of *M. crocata*.
cinerea Mass. & Crossl.—? form of *aetites*.
citrinella (Pers.) Fr.—a doubtful species. Ricken records it for Germany, but his spores and cystidia suggest *M. flavo-alba*.
clavicularis Fr.—variously interpreted; excluded for further observation.
clavus (Linn.) Rea = *M. Adonis*.
coccinea (Sow.) Quél. = *M. Adonis*.
codoniceps Cke.—description inadequate.
collariata Fr.—identity uncertain.
consimilis Cke.—Ill. 1150 (1186) is typical *M. ammoniaca*.
cruenta Fr. = *M. haematopus*.
debilis Fr.—left in list, but wants clearer definition.
dilatata Fr.—probably *M. stylobates*.
discopus Lev.—probably *M. stylobates*.
dissiliens Fr.—has different interpretations; we do not know to which the British record refers.
excisa (Lasch) Gillet.—probably *M. galericulata*.
farrea (Lasch) Fr.—may be *Lepiota sistrata*.
fillea Lange = *M. erubescens* v. Höhnelt.
fusco-purpurea (Lasch) Cke.—uncertain.
galericulata var. *calopus* Fr. = *M. inclinata*.
Iris Berk. = *M. amicta* Fr.
juncicola Fr.—description inadequate but has distinctive characters.
leptocephala (Pers.) Fr.—seems identical with *M. alcalina*.
lineata (Bull.) Fr.—authors take different views about this. It is perhaps best to consider it a pale form of *M. chlorantha*. A.A.P.
luteo-alba (Bolt.) Fr.—identity doubtful.
marginella Fr.—Cke. Ill. 1148 (957) appears to be *M. amicta*.
nivea Quél. = *M. gypsea*.
olivaceo-marginata Mass. = *M. avenacea* Fr. The smaller spores given by Masee are presumably an error.
parabolica Fr.—has many interpretations. Best left out.
paupercula Berk.—no microscopic details given.
peltata Fr.—identity uncertain.
plicato-crenata Fr.—hardly distinct from *M. epipterygia*.
plicosa Fr.—variously interpreted; withdrawn until more fully described from British specimens.
plumbea Fr.—doubtful.
prolifera (Sow.) Fr.—Sowerby's figure t. 169 suggests *M. inclinata*.
psammicola B. & Br.—not clearly defined. Alex. Smith describes it from American specimens as like a *Galera*.
pseudo-pura Cke.—usually considered to be a form of *M. pura*, but restored to specific rank by Kühner who states that the spores are non-amyloid. We have not been able to verify this as it appears to be a rare species in Britain. *M. pura* has amyloid spores.
pullata Berk. & Cke.—uncertain.
pura var. *carnea* Rea = var. *rosea* Schum.
rubro-marginata Fr.—we interpret this as being the *Mycena* which grows in vast numbers under conifers, with much the same smell as *M. ammoniaca* and *M. alcalina*. Fries in his *Monographia* says 'est inter vulgatissimas Mycenas'. It is true that he calls it 'inodorus', but his sense of smell was defective, and sometimes the smell is weak or absent. Kühner describes the species under *M. capillaripes*, Peck and Lange as *M. plicosa* var. *marginata*.
rugosa Fr.—a rugose form of *M. galericulata*.

saccharifera B. & Br.—probably *M. tenerrima*.

setosa (Sow.) Fr. = *M. Mucor*.

Seynii Quél.—usually considered as confined to southern Europe, but has been recorded in

Holland, so our one British record may be correct.

Simillima Karst.—identity uncertain.

stannea Fr.—probably a form of *M. aetites* when dry.

strobilina Fr. = *M. Adonis*.

sudora—doubtful species.

tenuis (Bolt.) Fr.—not clearly defined.

tenella = *M. metata*.

tintinnabulum Fr.—has many interpretations; not known to which the British record refers.

trachyspora Rea—a good species, but the spores are smooth. Specimens from the trunk on which the original material grew are in the Kew herbarium, Royal Botanic Gardens.

Unfortunately the name cannot be changed.

urania Fr.—left in list, but this striking species awaits further study. The epithet has been adopted by Alex. Smith for an American species with warted cystidia. Its occurrence as British rests solely on Massee's authority and requires confirmation.

vitrea Fr.—variously interpreted and best withdrawn. Cke. Ill. 237 (160) is probably *M. subalpina*.

Gen. COLLYBIA Fr.

(*Oudemansiella* Speg. (1882) and

Mucidula Pat. (1887))

Collybia radicata (Rehl) Berk.

(*Xerula* Maire)

Collybia longipes (Bull.) Berk.

Eu-Collybiae

Laevipedes Fr.

Collybia nitellina Fr.

extuberans Fr.

collina (Scop.) Fr.

succinea Fr.

nummularia Fr.

thelephora Cke. & Mass.

Vestipedes Fr.

Collybia velutipes (Curt.) Fr.

f. *rubescens* Cke.

f. *lactea* Quél.

cirrata (Schum.) Fr.

var. *Cookei* Bres.

var. *ocellata* Fr.

tuberosa (Bull.) Fr.

racemosa (Pers.) Fr.

Stevensonii B. & Br.

Striaeepedes Fr.

Collybia platyphylla (Pers.) Fr.

fusipes (Bull.) Berk.

maculata (A. & S.) Fr.

distorta Fr.

butyracea (Bull.) Fr.

floccipes Fr.

lacerata (Lasch) Berk.

eriocephala Rea

Tephrophanae Fr.

Collybia rancida Fr.

protracta Fr.

putida (Fr.) Konr. & Maubl.

inolens Fr.

mephitica Fr.

coracina Fr.

murina (Batsch) Fr.

misera (Fr.) Lange non Bres.

atrata Fr.

ambusta Fr.

clusilis Fr.

pseudo-clusilis Joss. & Konr.

tylicolor Fr.

tesquorum (Fr.) Bres.

palustris (Peck)

NOTES

Collybia acervata Fr. = *Marasmius acervatus*.

caldarii Berk.—an alien.

cirrata var. *Cookei* Bres.—recorded by Bresadola in *Icon. Myc.* (1928), tab. 206, and based on Cke. Ill. 197 (144), lower figure. It is *cirrata* with a yellow sclerotium; the type has none.

collina (Scop.) Fr.—left in list but requires confirmation.

confluens Fr. = *Marasmius confluens*.

Collybia conigena Fr.—see *Marasmius* notes.

crassifolia (Berk.) Bres. = *Tricholoma immundum* Berk.

Dorotheae Berk.—an alien.

dryophila (Bull.) Fr. = *Marasmius dryophilus*.

eriocephala Rea—may only be a form of *C. fusipes* but left in for further observation.

esculenta (Wulf.) Fr. = *Marasmius esculentus*.

eustygia Cke. = *Tricholoma immundum*.

floccipes Fr.—Cke. Ill. 1142 (1168) looks authentic enough to be kept in the list but confirmation is needed.

fodiens Kalch.—? form of *maculata*.

fumosa (Pers.) Quél. non Fr. = *Tricholoma immundum*.

Henriettae W. G. Sm.—probably a form of *C. radicata*.

infumata (Bres.) Rea = *Tricholoma infumatum*.

lanripes Fr.—slender form of *C. fusipes*.

laxipes (Batt.) Fr.—identity uncertain. Cke. Ill. 191 (184) is probably *Marasmius undatus*.

leucomyosotis Cke. & Smith (1885) = *Mycena palustris* Peck (1872), recorded in this list

palustris.

luteifolia Gillet—probably *Marasmius dryophilus* var. *funicularis*.

macilenta Fr.—record doubtful. Cke. Ill. 208 (268) represents *Marasmius dryophilus* var. *funicularis*.

mimica W. G. Sm.—probably *Naucoria cucumis*.

muscigena (Schum.) Fr. ? = *Mycena gypsea*.

nummularia Fr.—left in list, but doubtful whether the British record is other than *Marasmius dryophilus*.

ozes Fr.—doubtful record.

planipes (Brig.) Fr.—? form of *C. radicata*.

plexipes Fr.—? = *C. protracta*.

prolixa (Fl. Dan.) Fr.—can hardly be distinct from *C. distorta*.

psathyroides Cke.—needs confirmation; probably a *Mycena* but may be a form of *C. radicata*.

pulla (Schaeff.) Fr.—may be a form of *C. butyracea*.

retigera Bres.—doubtful record.

semitalis Fr. = *Tricholoma semitale*.

Stevensonii B. & Br.—left in list but not known to modern authors.

stridula (Schaeff.) Fr. = *Tricholoma melaleucum*.

tesquorum Fr.—identity doubtful. It was identified by Lange with the rough-spored *C. tylicolor*, but later he preferred to associate the epithet with a smooth-spored agaric as *Bresadola* already had done. It is left in the list with this interpretation.

ventricosa (Bull.) Fr.—? form of *C. radicata*.

xanthopus Fr. = ? *M. dryophilus*.

xylophila (Weinm.) Fr.—may be *Mycena galericulata*.

Gen. MARASMIUS Fr.

Collybioides

(a) *Inodori*

Marasmius peronatus (Bolt.) Fr.

fusco-purpureus (Pers.) Fr.

acervatus (Fr.) comb. nov.

lupuletorum (Weinm.) Fr.

ceratopus (Pers.) Quél.

confluens (Pers.) Karst.

pruinatus Rea

obtusifolius Rea

oreades (Bolt.) Fr.

oreadoides (Pass.) Fr.

Marasmius Wynnei B. & Br.

dryophilus (Bull.) Karst.

var. *funicularis* (Fr.) Rea

var. *aquosus* (Fr.) Rea

exculptus (Fr.) Rea

undatus Berk.

(b) *Alliodori*

Marasmius porreus (Pers.) Fr.

prasiosmus Fr.

scorodonius Fr.

alliaceus (Jacq.) Fr.

(c) *Ingrati*

Marasmius foetidus (Sow.) Fr.
impudicus Fr.
perforans Fr.

(d) *Conigeni*

Marasmius esculentus (Wulf ex Fr.)
Karst.

(e) (*Baeospora* Singer)

Marasmius myosurus (Wulf ex Fr.)
Karst.

Mycenoides

(a) *Ramealini*

Marasmius ramealis (Bull.) Fr.
Vaillantii (Pers.) Fr.

Marasmius Menieri Boud.
tricolor (A. & S.) Fr.
amadelphus (Bull.) Fr.

(b) (*Androsaceus* (Pers.) Pat.)

Marasmius rotula (Scop.) Fr.
graminum Lib.
obtusifolius Rea
androsaceus (Linn.) Fr.
splachnoides Fr.
epiphyllus (Pers.) Fr.
epiphylloides (Rea) Sacc. & Trotter
Hudsonii (Pers.) Fr.

(c) (*Xeromphalina* Kühner & Maire)

Marasmius cauticinalis (With.) Fr.

Gen. **CRINIPELLIS** Pat.

Crinipellis stipitarius (Fr.) Pat.

NOTES

Marasmius actinophorus B. & Br.—may be *M. graminum*.
amadelphus (Bull.) Fr.—left in, but confirmation needed.
angulatus (Batsch) B. & Br.—probably *M. Vaillantii*.
archyropus (Pers.) Fr.—doubtful identity.
calopus (Pers.) Fr. = *M. scorodoni*, inodorous form.
candidus (Bolt.) Fr. = *M. Vaillantii*.
caulicinalis (Bull.) Quél. = *Crinipellis stipitarius*.
cohaerens (A. & S. ex Fr.) Cke. = *M. ceratopus* (Pers. 1828) Quél.
conigenus (Pers. ex Fr.) Karst. = *M. myosurus*. In the *Syst. Myc.* *myosurus* comes first, followed by *conigenus* for the same species. As the latter epithet has been used by several authors for other species, it is better to adopt *myosurus* as less confusing for the brownish agaric common on pine cones in the autumn.
Curreyi B. & Br. = *M. graminum*.
epichloe Fr. = *Crinipellis stipitarius*.
erythropus (Pers.) Fr. = *M. acervatus*. The epithet *erythropus* has also been used for other species and is best withdrawn.
flosculus (Bat.) Rea—doubtful record.
Friesii (Bres.) Rea = *M. myosurus*.
globularis Fr. = *M. Wynnei*.
hariolorum (DC.) Quél. = *M. confuens*. The *hariolorum* in the *Syst. Myc.* is that of Bulliard which is a mixture of two species.
inodorus Pat.—listed for Britain in error.
ingratus (Schum.) Quél.—appears to be *M. confuens*.
insititius Fr. = *M. Vaillantii*.
lagopinus von Post—doubtful record.
languidus (Lasch) Fr.—suggests *M. Vaillantii*.
molyoides Fr.—doubtful record.
plancus Fr.—not clearly defined. Cke. Ill. 1073 (1119) suggests *Collybia extuberans*.
polyadelphus (Lasch) Cke. = *Mycena polyadelpha*.
rubricatus (B. & Br.) Masee—probably *M. ramealis*.
saccharinus Batsch—identity in doubt.
sclerotipes Bres. = *Collybia cirrata* var. *Cookei* Bres.
scorteus Fr.—Cke. Ill. 1073 (1119) is form of *M. Wynnei*.
spodoleucus B. & Br.—probably *Pleurotus cyphellaeformis*.

Marasmius suaveolens Rea = *M. Wynnei* but for globose spores.

tenacellus (Wulf ex Fr.) Karst.—in the *Syst. Myc.* both *esculentus* and *tenacellus* are used for the same species, but *esculentus* is described as growing in April and May. It is therefore the valid name, though *tenacellus* seems to be most in favour for this common spring fungus on pine cones.

terginus Fr. = *M. fusco-purpureus*.

torquatus Fr.—doubtful record.

torquescens Quél.—also doubtful.

undatus (Berk.) Quél.—left in, but said to be identical with *M. porreus*, though the garlic smell is not usually detected in the fairly common species which we call *M. undatus*.

urens (Bull.) Fr. = *M. peronatus*. Both epithets are in *Syst. Myc.*, but *urens* is placed among the brown-spored group, most of which are *Cortinari*.

varicosus Fr.—has many interpretations; that of Boudier, *Icon. t. 72* is usually accepted, but the British record is uncertain.

xerotoides von Post—doubtful record.

Crinipellis caulicinalis (Bull.) Rea = *C. stipitarius*.

Gen. OMPHALIA Fr.

Griseo-cinereae

Omphalia hydrogramma (Bull.) Fr.

umbilicata (Schaeff.) Fr.

philonotis (Lasch) Fr.

sphagnicola Berk.

oniscus Fr.

epichysium (Pers.) Fr.

telamatiæa Berk. & Cke.

glaucophylla (Lasch) Cke.

leucophylla (A. & S.) Fr.

atropuncta (Pers.) Fr.

maura Fr.

Pyxidatæ Fr.

Omphalia pyxidata (Bull.) Fr.

muralis (Sow.) Fr.

hepatica (Batsch) Fr.

umbratilis Fr.

Postii Fr.

var. *aurea* Mass.

rustica Fr.

chrysophylla Fr.

Wynniae (B. & Br.) Quél.

Allenii Maire

striaepileæ Fr.

demissa Fr.

rosella Lange

Belliae Johnst.

Umbelliferae

Omphalia umbellifera (Linn.) Fr.

var. *nivea* Fl. Dan.

var. *flava* Cke.

var. *pallida* Cke.

viridis (Fl. Dan.) Lange

Omphalia myochroa (Fr.) Rea

grisella (Weinm.) Karst.

retosta Fr.

abhorrens B. & Br.

Graciles

Albidae

Omphalia gracilis Quél.

gracillima Weinm.

stellata Fr.

candida Bres.

scyphiformis Fr.

Mairei Gilbert

Reliquæ

Omphalia fibula (Bull.) Fr.

var. *Swartzii* Fr.

var. *nivalis* Fl. Dan.

picta Fr.

camptophylla Berk.

griseo-pallida Desm.

Brownii (B. & Br.) Favre.

(See also *Mycena* for several species with decurrent gills)

(*Delicatula* Fayod.)

Omphalia integrella (Pers.) Fr.

gibba (A. & S.) Pat.

(*Xeromphalina* Kühner & Maire)

Omphalia campanella (Batsch) Fr.

var. *papillata* Fr.

var. *myriodea* Kalch.

(See also *Marasmius caucinalis*)

NOTES

Omphalia abhorrens B. & Br.—not known, but its smell and habitat is distinctive enough to justify its retention.

albido-pallens Karst.—identity uncertain, and no authentic British record can be traced.

alutacea Cke. & Mass.—hardly distinct from *O. pyxidata*.

atropuncta (Pers.) Quél.—left under *Omphalia* though Lange transfers it to *Hygrophorus* (*Camaro-phyllus*).

Brownii (B. & Br.) Favre—transferred from *Cantharellus* by Favre (*Bull. Soc. mycol. Fr.* LV, 212) who cites Cke. *Ill.* 1058 (1106), so it is retained among the British records.

buccinalis (Sow.) Cke.—a so-called common species which nobody has ever seen since Sowerby's day.

bullata (Brig.) Cke.—description inadequate.

caespitosa (Bolt.) Cke. = *O. umbellifera* var. *flava*.

campanella var. *badius* Fr. = *Marasmius caudicinalis*.

detrusa Fr.—crept into British fungus flora by mistake.

directa B. & Br.—description inadequate.

glaucophylla (Lasch) Fr.—left in, but Cejp suggests it may be a terrestrial form of *O. epichysium*.

grisea Fr.—variously interpreted but not really known. Often confused with *Mycena cinerella* but Fries wrote: '*in pinetis rara et nobilis species*'. Better left out till British specimens are more clearly defined.

hepatica (Batsch) Fr.—left in, but needs clearer definition to distinguish it from *O. pyxidata*.

Cejp thinks them distinct.

hydrogramma (Bull.) Fr.—this has more affinity with *Clitocybe* to which it may be transferred.

The same may be said of *Omphalia umbilicata*.

infumata B. & Br.—not known; suggests *O. chrysophylla*.

Kewensis Mass.—an alien on filmy fern.

Luffii Mass.—may be a form of *Clitocybe fragrans*.

Nevillae Berk.—an alien in orchid house.

officiata Fr.—not known; almost suggests *Laccaria laccata*.

pseudo-androsacea (Bull.) Fr. = *O. umbellifera*.

pseudo-directa W. G. Sm.—no spores given.

scyphoides Fr.—doubtful identity; probably *Clitopilus cretatus*.

sphagnicola Berk.—this rare species is (sec. Cejp) distinct from *O. philonotis*.

telmatiae Berk. & Cke.—left in list for the present, but may be large form of *O. philonotis*.

tricolor (A. & S.) Fr. = *Marasmius tricolor*.

umbellifera var. *citrina* Quél. = *O. Wynniae*.

velutina Quél. = *O. grisella*.

Gen. PLEUROTUS Fr.

Pleurotus ostreatus (Jacq.) Fr.

var. *columbinus* (Quél.) Cke.

var. *salignus* (Pers.) Fr.

var. *euosmus* (Berk.) Cke.

cornucopiae (Paulet) Persoon

ulmarius (Bull.) Fr.

porrigens (Pers.) Fr.

lignatilis Fr.

dryinus (Pers.) Fr.

mutilus Fr.

Pleurotus atrocaeruleus Fr.

serotinus (Schröd.) Fr.

var. *Almenii* (Fr.) Big. & Guill.

(b) *Cystidia absent*

Pleurotus applicatus (Batsch) Fr.

Silvanus Sacc.

cyphelliformis Berk.

Lauro-cerasi B. & Br.

Leightonii Berk.

(*Acanthocystis* Fayod)

(a) *Cystidia present*

Pleurotus petaloides (Bull.) Fr.

var. *geogenius* (DC) Pilat

mastrucatus Fr.

reniformis Fr.

(*Pleurotellus* Fayod)

Pleurotus chioneus (Pers.) Fr.

septicus Fr.

hypnophilus Berk. sensu Sacc., Rea,

etc., non Quél.

dictyorrhizus (DC) Fr.

(Pleurotellus Fayod) (continued)

Pleurotus acerosus Fr.
tremulus (Schaeff.) Fr.
candidissimus Berk. & Curt.

(Panellus Kühner)
Pleurotus mitis (Pers.) Berk.
(Rhodotus Maire)
Pleurotus palmatus (Bull.) Fr.

NOTES

Pleurotus acerinus Fr. = *P. dryinus*.

acerosus sensu Rea = *P. tremulus*.

algidus Fr. = *P. atrocaeruleus* (sec. Pilat).

applicatus—with elliptical spores sensu Rea is *P. Silvanus* which we have listed. *P. applicatus* has globose spores 4–5 μ , and as it is said to be a common species, we have not removed it.

circinatus Fr.—probably *P. lignatilis*.

corticatus Fr. = *P. dryinus*.

craspedius Fr.—doubtful species. Cke. Ill. 274 (256) is *P. ulmarius*.

fimbriatus (Bolt.) Fr. = form of *P. lignatilis*.

fluxilis Fr.—doubtful; Pilat suggests it may be *P. unguicularis* Fr.

gadinoideus W.G.Sm. = *P. dictyorrhizus*.

Hobsonii Berk.—probably *P. chioneus*.

hypnophilus Berk.—this epithet has been applied to two species. It is left in the list as applying to the species with minute spores. Pilat adopts the interpretation of Quélet, the spores given being 6–8 \times 2.6–3 μ , but this may be a form of *P. septicus*.

Leightonii Berk.—also left in list, but Cke. Ill. 290 (260) is *P. atrocaeruleus*.

limpidus Fr.—doubtful species.

pantoleucus Fr. = *P. dryinus*. Cooke's figure 277 (179) is either *Panus torulosus* or *Pleurotus palmatus*.

pulmonarius Fr. = *P. ostreatus*.

revolutus Kickx. = *P. ostreatus*.

rufipes Mass. & Smith—Pilat says this may be *P. mitis* with stem coloured by contact.

Ruthae B. & Br.—form of *P. petaloides* according to Pilat who examined specimens at Kew.

sapidus Schulzer, 1873 = *P. cornucopiae* (Paulet) Persoon, 1828.

spongiosus Fr. = *P. dryinus*.

striatulus Fr. = *P. applicatus*.

tessulatus (Bull.) Fr. = *P. ulmarius*.

tremulus sensu Rea = *P. acerosus*.

Gen. PANUS Fr.

Panus torulosus (Pers.) Fr.
rudis Fr.

(*Panellus* Karst.)
Panus stipticus Karst.
var. *farinaceus* (Schum.) Rea

Gen. LENTINUS Fr.

Lentinus tigrinus (Bull.) Fr.
lepideus Fr.
adhaerens (A. & S.) Fr.

(*Lentinellus* Karst. em. Kühner)

Lentinus cochleatus (Pers.) Fr.

Lentinus omphalodes Fr.
var. *scoticus* (B. & Br.) Pilat
vulpinus (Sow.) Fr.
f. *auricula* (Fr.) Pilat

Gen. SCHIZOPHYLLUM Fr.

Schizophyllum commune Fr.

Gen. NYCTALIS Fr.

Nyctalis parasitica (Bull.) Fr.

Nyctalis asterophora Fr.

NOTES

- Panus conchatus* (Bull.) Fr. = *P. torulosus*.
patellaris Fr.—British record doubtful. Cke. III. 1097 (1144) has spores $4 \times 3 \mu$, but Pilat's measurements are $3-4 \times 0.8-1.3 \mu$.
Stevensonii B. & Br. = *Pleurotus nidulans*.
Xerotus degener Fr. = *Lentinus cyathiformis*, but Cke. III. 1098 (1150) looks like *Collybia clusilis*.
Lentinus auricula Fr.—form of *L. vulpinus*.
fimbriatus Currey = *L. tigrinus*.
flabelliformis (Bolton) Fr. = *L. omphalodes*.
flabellinus Qué. = *L. omphalodes*.
leontopodius Schulz. = *L. cyathiformis*, but the British record of this rare species is doubtful.
pulverulentus (Scop.) Fr. = *L. adhaerens*.
scoticus B. & Br. = var. of *L. omphalodes*.
sulcatus Berk.
suffrutescens (Brot.) Fr.—probably *L. lepideus*.
umbellatus Fr. = *L. cochleatus*.

Gen. **HYGROPHORUS** Fr.I. (*Limacium* Fr.)A. *Candidi* Bat.

- Hygrophorus eburneus* (Bull.) Fr.
coscus (Sow.) Fr.
chrysodon Fr.
penarius Fr.
discoxanthus (Fr.) Rea

B. *Pudorini* Bat.

- Hygrophorus Russula* (Schaeff.) Qué.
erubescens Fr.
pudorinus Fr.

C. *Luteoli*

- Hygrophorus lucorum* Kalch.
discoideus (Pers.) Fr.
leucophaeus (Scop.) Fr.
arbustivus Fr.
aureus (Arrh.) Fr.

D. *Olivaceo-umbrini* Bat.

- Hygrophorus olivaceo-albus* Fr.
 var. *obesus* (Bres.) Maire
limacinus (Scop.) Fr.
squamulosus Rea
fusco-albus Fr.
cerasinus Berk.
hypothejus Fr.

E. *Griseoli*

- Hygrophorus agathosmus* Fr.
 var. *aureo-floccosus* Bres.
pustulatus (Pers.) Fr.
livido-albus Fr.

II. (*Camarophyllus* Fr.)*Decurrentes*

- Hygrophorus camarophyllus* (A. & S.) Fr.
nemoreus (Lasch) Fr.
pratensis (Pers.) Fr.
 var. *pallidus* B. & Br.
cinereus (Fr.) Karst.
Karstenii Sacc. & Cub.
virgineus (Wulf.) Fr.
 var. *roseipes* Mass.
niveus (Scop.) Fr.
russo-coriaceus Berk. & Miller
subradiatus (Schum.) Fr.
lacmus Fr.
Colemannianus Blox.

Adnati

- Hygrophorus fornicatus* Fr.
citrino-virens Lange
ovinus (Bull.) Fr.
metapodius Fr.
lepidopus Rea

III. (*Hygrocybe* Fr.)(a) *Conici* Bat.

- Hygrophorus conicus* Fr.
nigrescens Qué.
intermedius Pass.
obrusseus Fr.
calyptraeformis Berk.
 var. *niveus* Cke.

(b) *Coccinei* Bat.

Hygrophorus coccineus (Schaeff.) Fr.
punicus Fr.
miniatus Fr.
Reai Maire
mucronellus Fr.
sciophanus Fr.
sciophanoides Rea
turundus Fr.
 var. *mollis* B. & Br.

(c) *Flaveoli*

Hygrophorus psittacinus (Schaeff.) Fr.
ceraceus (Wulf.) Fr.
citrinus Rea
chlorophanus Fr.
vitellinus Fr.
laetus (Pers.) Fr.
micaceus B. & Br.

(d) *Tristes* Bat.

Hygrophorus unguinosus Fr.
nitratus (Pers.) Fr.
foetens Phill.

NOTES

Hygrophorus amoenus Lasch (1828)—most continental authors synonymize this with *H. calyptraeformis* Berk. (1860), but the original description by Lasch in *Linnaea*, vol. III, p. 390, gives the essential characters as '*Pileo...obtusio, striato, subaurantiaca, lamellis decurrentibus*', all of which are different from *H. calyptraeformis*.

aromaticus (Sow.) Berk.—may be a form of *H. laetus*.

Clarkii B. & Br. = *H. unguinosus*.

clivalis Fr. = *H. fornicatus*.

connatus Karst.—? form of *H. unguinosus*.

distans Berk. = *H. fornicatus*.

glutinifer Fr.—variously interpreted. Cke. III. 878 (889) is probably *H. olivaceo-albus*.

irrigatus (Pers.) Fr. = *H. unguinosus*.

leporinus Fr. = *H. nemoreus*.

melizeus Fr.—does not seem distinct from *H. eburneus*.

mesotephrus B. & Br. = *H. leucophaeus*.

niveus (Scop.) Fr. var. *fuscescens* Bres. = *H. subradiatus*.

obscuratus Karst.—probably *H. nitratus*.

persicinus Beck.—suggests a form of *Cantharellus cibarius*.

pratensis var. *cinereus* Fr. = *H. cinereus*.

puberulentus B. & Br.—known only from three rather dubious old records.

sciophanoides Rea—left in, but may be *H. laetus*.

spadiceus (Scop.) Fr.—record doubtful. Cke. III. 1194 (1161) with its small spores is probably *H. hypothejus*.

squamulosus Rea—left in, but suggests a *Tricholoma* near *sejunctum*. It was originally recorded from Clare Island, west of Ireland.

streptopus Fr. = *H. fornicatus*.

tristis (Pers.) Bres. = *H. nigrescens*.

turundus var. *sphaerosporus* Rea—this can hardly be correct. The spores as figured in original drawing are those of a *Laccaria*.

ventricosus B. & Br.—form of *H. virgineus*.

Wynniae B. & Br. = *Omphalia Wynniae*.

Gen. *LACTARIUS* Fr.

I. *Glutinosi* Quél.

A. *Barbati* Quél.

Lactarius scrobiculatus (Scop.) Fr.

resimus Fr.

repraesentaneus Britz.

Lactarius torminosus Fr.

cilicioides Fr.

pubescens Fr.

plumbeus Fr. (= *turpis* Fr.)

controversus (Pers.) Fr.

B. *Glabrati* Bataille

(1) *Colorenti*

Lactarius deliciosus (Linn.) Fr.
uvidus Fr.
violascens Fr.
aspideus Fr.
chrysorheus Fr.
vietus Fr.
blennius Fr.
umbrinus (Pers.) Fr.
 (See also *L. theiogalus*)

(2) *Immutabiles*

Lactarius zonarius (Bull.) Fr.
insulsus Fr.
pyrogalus (Bull.) Fr.
flexuosus Fr.
 var. *roseo-zonatus* Fr.
circellatus (Batt.) Fr.
hysginus Fr.
trivialis Fr.
pallidus (Pers.) Fr.

II. *Velutini* Quél.

(1) *Albati* Bat.

Lactarius vellereus Fr.
piperatus (Scop.) Fr.

(2) *Rubescenti*

Lactarius fuliginosus Fr.
picipinus Fr.
lignyotus (Lindb.) Fr.
acris (Bolt.) Fr.

(3) *Olentes*

Lactarius helvus Fr.
camphoratus (Bull.) Fr.
seriffuus (DC.) Fr.
cimicarius (Batsch) Cke.
quietus Fr.
glycyosmus Fr.

(4) *Acri*

Lactarius rufus (Scop.) Fr.
mammosus Fr.
lilacinus (Lasch) Fr.

(5) *Subdulces* Konr.

Lactarius volemus Fr.
ichoratus (Batsch) Fr.
subdulcis (Pers.) Fr.
aurantiacus (Fl. Dan.) Fr.
mitissimus Fr.
cremor Fr.
cyathula (Fr.) Ricken
obnubilus (Lasch) Fr.
thiogalus Fr. non Bull.
hepaticus Plow.

NOTES

Lactarius acris (Bolt.) Fr.—left in with some doubt, as it hardly differs from *L. fuliginosus*.
capsicum Schulz.—not known.

chrysorheus Fr. *Epicr.* 1836-8. There can be little doubt that this is the same as *L. theiogalus* (Bull.) Fr. *Syst. Myc.*, though in later works Fries identified the latter name with a zoneless agaric, the milk of which tardily turns yellow. To avoid confusion we have left both epithets in the list.

circellatus Fr.—it is not clear whether this differs from *L. flexuosus*.

flavidus Boud.=*L. aspideus*.

flexuosus Fr.—see note on *L. circellatus*. Both kept in list.

fluens Boud.=*L. blennius*.

involutus Soppitt.—spores in Cke. *Ill.* 1195 (1194) not of a *Lactarius*.

lateritioroseus Karst.=*L. lilacinus*.

lividus Lamb.—not known and description inadequate.

mammosus Fr.—left in, but hardly known.

minimus W.G.Sm.—dwarf form of *L. subdulcis*.

obliquus Fr.—not known. Cke. *Ill.* 969 (1014) may be form of *L. trivialis*.

obnubilus (Lasch) Fr.—left in but variously interpreted, so a clear description of British record is needed.

pergamenus Swartz=*L. piperatus*.

representaneus Britz.—very like *L. scrobiculatus* but milk turns violet. Found at Rothiemurchus, Scotland, some years ago, when it was listed as *L. aspideus*.

resimus Fr.—doubtful if distinct from *L. scrobiculatus*, but left in for further study.

retisporus Mass.—dark form of *L. fuliginosus*.

sanguifluus (Paul.) Fr.—a southern European species.

* *Lactarius scoticus* B. & Br.—figure in Cke. *Ill.* 938 (1004) suggests *L. pubescens*.

spinosulus = *L. lilacinus*.

squalidus (Krombh.) Fr.—of dubious identity.

subumbonatus Lindgr.—considered to be either *L. cimirarius* or *L. camphoratus*.

tomentosus (Otto) Cke.—not known; probably *L. tomentosus*.

tabidus Fr.—variously interpreted. Sensu Boudier = *L. cyathula*.

turpis Fr. = *plumbeus* Fr. *Syst. Myc.* (1821). Much as we dislike disturbing this familiar name, *plumbeus* has priority. Another name for the same species, *necator* Pers., also appears in the *Syst.* but has been confused with *terminosus*. It is therefore best to adopt *plumbeus*, though Bresadola discarded it because it is a '*nomen ineptum*'; but that is not a valid reason for excluding it.

umbrinus (Pers.) Fr.—remains in list, but this rare and little known species has not been found for years.

utilis (Weinm.) Fr.—doubtful. Cke. *Ill.* 930 (1084) may be *L. delicata*.

Gen. RUSSULA Fr.

I. *Lactariodes*

Russula nigricans Fr.
densifolia (Secr.) Gill
adusta Fr.
albo-nigra Krombh.
delicata Fr.

II. *Rigidae* Fr.

Russula mustelina Fr.
virescens (Schaeff.) Fr.
lepida Fr.
 var. *amara* Maire
lactea (Pers.) Fr.
rosea Quél.
 f. *aurora* Pearson
azurea Bres.
amoena Quél.

III. *Resilientes*

Russula cyanoxantha (Schaeff.) Fr.
heterophylla Fr.
 var. *virginica* (Cke. & Mass.) comb. nov.
vesca Fr.
farinipes Romell

IV. *Foetentes* Kühner & Joss.

Russula foetens Fr.
laurocerasi Melz.
pectinata (Bull.) Fr.
sororia Fr.
consobrina Fr.

V. *Acrae*

(a) *Leucosporae*

Russula emetica (Schaeff.) Fr.
 Mairei Singer
 luteo-tacta Rea
 fragilis Fr.
 var. *nivea* (Pers.) Cke.
 fallax (Fr.) Cke.

(b) *Pallidisporae*

Russula violacea Quél.
sanguinea (Bull.) Fr.
Queletii Fr.
dreimeia Cke.
 var. *viridis* Singer
fellea Fr.

(c) *Xanthosporae*

Russula rubra (Kromb.) Bres.
badia Quél.
maculata Quél.
luteo-viridans Martin
nitida (Pers.) Fr.

VI. *Sub-acrae*

Russula atro-purpurea Kromb.
 var. *depallens* (Cke.) Maire
ochroleuca Fr.
solaris Ferd. & Winge
pseudo-integra Arn. & Goris
veternosa Fr.
exalbicans Bres.
versicolor J. Schaeffer
gracillima J. Schaeffer

VII. *Gratae*

(a) *Pallidisporae*

Russula grisea (Pers. ex Secr.) Fr.
aeruginea Lindb.
melliolens Quél.
 var. *Chrysantiae* Maire
puellaris Fr.
 var. *leprosa* Bres.
brunneo-violacea Crawshaw
lilacea Quél.

(b) *Xanthosporae*

- Russula xerampelina* Fr.
 var. *fusca* (Quél.) Melz. & Zv.
 var. *erythropus* Pelt.
 var. *olivascens* (Fr.) Melz. & Zv.
decolorans Fr.
claroflava Grove
vinosa Lindb.
alutacea (Pers.) Fr.
olivacea (Schaeff.) Fr.
Romellii Maire
integra (Linn.) Fr.
- Russula caerulea* Cke.
Turci Bres.
Velenovskyi Melz. & Zv.
paludosa Britz.
aurata (With.) Fr.
lutea Fr.
 f. *luteorosella* Britz.
venosa Vel.
Scotica Pearson
nauseosa (Pers.) Fr.
 (See under *Sub-acrae* for species that may be mild or acrid)

NOTES

- Russula armeniaca* Cke. = *R. lutea* var. *luteorosella* Britz.
aurora Krombh.—there is some doubt whether this is a variety of *R. lepida* or identical with *R. rosea* Quél. It is left in the list as a peach-coloured form of *R. rosea*, as described in *Trans. Brit. mycol. Soc.* xxxii, 36.
carnicolor Bres. = *R. lilacea*.
chamaeleontina Fr.—variously interpreted; not clear what the British records refer to. Cke. *Ill.* 1054 (1098) is a mixed bag.
citrina Gillet—bright yellow form of *R. ochroleuca*.
constans (Karst.) Romell = *R. claroflava*.
cutifracta Cke.—a much disputed species; nobody knows what it really is.
drimeia Cke.—many authors adopt *R. sardonica* Fr. for this species, but as Fries states that the gills are white, we prefer to retain Cooke's epithet for the species with primrose gills.
drimeia var. *flavo-virens* Rea (1932) = *R. drimeia* f. *viridis* Singer (1928).
elegans Bres.—? form of *R. xerampelina*.
elephantina Fr. = *R. delica*.
emetica Fr.—there are conflicting opinions about this species. The beechwood form is recorded in this list as *R. Mairei* Singer, but the other forms require further study before they can be definitely placed.
fragibilis Britz. = *R. ochroleuca*, which may be mild or acrid.
fragilis (Pers.) Fr.—there is no universal agreement about this species. It is often identified with a scarlet-capped *Russula* of the *emetica* group, but this can hardly be correct. Persoon described it as *pileo rubro purpurascens*, Fries in *Syst. Myc.* as *e purpureo exalbicat*. In *Hym. Eur.* Fries states that it often has an eroded edge to the gills. It seems, therefore, reasonable to identify the species with the small fragile *Russula* with a purplish red pileus and fimbriate gills which is so common in Britain.
furcata (Pers.) Fr.—usually considered as a green form of *cyanoxantha*.
fusca Quél. = either *R. mustelina* or a form of *R. xerampelina*.
galochroa Fr. = *R. heterophylla*.
graminicolor (Socr.) Quél. = *R. aeruginea*.
incarnata Quél. = *R. rosea* Quél.
Linnaei Fr.—a large form of *R. lepida*.
mitis Rea = *R. vesca*.
ochracea (A. & S.) Fr.—variously interpreted; usually considered to be *R. fellea*.
punctata (Gillet) Maire = *R. amoena* Quél.
rosacea (Pers.) Fr. = *R. sanguinea*.
roseipes (Socr.) Bres.—doubtful British record. It is quite distinct from *R. roseipes* Cke. *Ill.* 1035 (1081), which is *R. nitida* (Fr.) J. Schaeffer.
semi-crema Fr. = *R. densifolia*.
serotina Quél.—it is not clear what this is.
sphagnophila Kauffm.—this epithet was applied by Singer to a common and very variable *Russula* which grows in wet places usually under birch trees. Many names have been given to this species, and it was thought that *R. venosa* (Vel.) Melzer would be generally accepted. J. Schaeffer in *Ann. Myc.* xxxviii (1940) identifies it with the true *R. nitida* Fr. For the

present we prefer to leave *R. venosa* as the epithet which clearly identifies this common *Russula*, and *R. nitida* remains to indicate the acrid species which hitherto has been associated with this name.

Russula subfoetens W.G.Sm.—probably a form of *R. foetens*, but it is not known what it really refers to. *R. subfoetens* sensu Maire and also Melzer is *R. farinipes* Romell. Cke. Ill. 1016 (1047) looks like *R. lauro-cerasi*.

virinea Cke. & Mass.=var. of *R. heterophylla*.

violacea Quél.—though marked as 'common' by Rea the authentic *R. violacea* with its smell of laudanum is rare in Britain, and the agaric often determined under this name is either *R. brunneo-violacea* or another species with a violet pileus.

Gen. CANTHARELLUS Adans

Cantharellus cibarius Fr.

var. *albus* Fr.

var. *amethysteus* (Quél.) Maire

Friesii Quél.

carbonarius (A. & S.) Fr.

Cantharellus tubaeformis (Bull.) Fr.

lutescens (Pers.) Fr.

cinereus (Pers.) Fr.

cupulatus Fr.

Gen. NEUROPHYLLUM Pat.

Neurophyllum clavatum (Pers.) Pat.

Gen. LEPTOTUS Karst. em. Maire

Leptotus muscigenus (Bull.) Maire

retirugis (Bull.) Karst.

Leptotus lobatus (Pers.) Karst.

glaucus (Batsch) Maire

Gen. CRATERELLUS Fr.

Craterellus cornucopiodes (Linn.) Fr.

sinuosus Fr.

Craterellus amethysteus Rea

Gen. PLICATURA Peck

Plicatura crispa (Pers. ex Fr.) Rea

NOTES

Cantharellus albidus Fr.=*Clitocybe albida*.

aurantiacus (Wulf.) Fr.=*Clitocybe aurantiaca*.

Brownii B. & Br.=*Omphalia Brownii*.

Houghtonii Phill.—Cke. Ill. 1060 (1107) looks like a form of *Mycena galericulata*.

infundibuliformis (Scop.) Fr.=*C. tubaeformis*.

leucophaeus Nouel.=*C. carbonarius*.

replexus Fr.—doubtful identity.

Stevensonii B. & Br.=*Clitocybe albida*.

umbonatus (Gmel.) Fr.=*Clitocybe umbonata*.

Trogia crispa Fr.=*Plicatura crispa*.

Dictyolus Quél. (1886)=*Leptotus* Karst. (1879).

Craterellus crispus (Sow.) Fr.=*C. sinuosus*.

pusillus Fr.=*C. sinuosus*.

Gen. VOLVARIA Fr.

A. Viscidae

Volvaria speciosa Fr.

f. *gloiocephala* (DC.) Konrad &

Maublanc

media (Schum.) Fr.

media biloba Mass.

B. Sericellae

Volvaria pusilla (Pers.) Fr.

volvacea (Bull.) Fr.

Taylori Berk.

bombycina (Pers.) Fr.

surrecta (Knapp) Ramsb.

murinella Quél.

Gen. PLUTEUS Fr.

I. *Trichodermei* LangeA. *Coronati* Lange

- Pluteus cervinus* (Schaeff.) Fr.
 var. *atromarginatus* Konr.
 var. *patricius* (Schulz.) Fr.
 var. *eximius* (Saund. & Sm.) comb. nov.
Salicinus (Pers.) Fr.
petasatus (Pers.) Fr.
pellitus (Pers.) Fr.

B. *Depauperati* Lange

- Pluteus Bullii* Berk.
gracilis (Bres.) Lange
hispidulus (Fr.) Quél.

- Pluteus umbrosus* (Pers.) Fr. sensu Ricken
luteo-virens Rea

II. *Micacei* Lange

- Pluteus semi-bulbosus* (Lasch) Fr.
Godeyi Gillet
cinereo-fuscus Lange
nanus (Pers.) Fr.
 var. *lutescens* Fr.
chrysophaeus (Schaeff.) Fr.
phlebophorus (Ditmar) Fr.
marginatus (Quél.) Bres.
argenteo-griseus Rea
leoninus (Schaeff.) Fr.
coccineus (Mass.) Lange
violarius Mass.

Gen. PLUTEOLUS Fr.

- Pluteolus aleuriatus* Fr.
 var. *reticulatus* (Pers. ex Fr.) Lange

NOTES

- Volvaria Loveiana* Berk. = *V. surrecta* (Knapp) Ramsb.
media (Schum.) Fr.—is retained, but the identity of the British record is not clear. Lange gives the spores as $11-16 \times 7-8 \mu$. Rea has $5-6 \times 4 \mu$.
murinella Quél.—recorded in *J. Bot.* LXX (1932), but without microscopic details.
parvula (Weinm.) Fr. = *V. pusilla*.
temperata B. & Br.—hardly distinct from *V. pusilla*.
viperina Fr.—British record doubtful.
Pluteus cervinus—the usual varieties are left in, but they are mostly forms that occur on sawdust.
ephebius Fr.—not clearly defined. Cke. Ill. 307 (517) looks like a rather large *Pluteolus aleuriatus*.
melanodon (Secr.) Fr.—doubtful identity.
nanus var. *major* Mass. = *P. cinereo-fuscus*.
roseo-albus Fr.—inadequately described.
spilopus B. & Br.—may be a form of *P. cervinus*.
sororiatius Karst.—not known; may be a *Pluteolus*.
umbrinellus (Sommerf.) Fr.—appears to be a pale form of *P. nanus*.
violarius Mass.—left in because it has distinctive characters, but it has not been found since first collected.
Pluteolus Mulgravensis Mass. & Crossl.—probably *P. aleuriatus*.

Gen. CLITOPILUS Fr.

- Clitopilus prunulus* (Scop.) Fr. *Clitopilus cretatus* B. & Br.

Gen. RIPARTITES Karst.

- Ripartites tricholoma* (A. & S.) Karst.

NOTES

- Clitopilus* Fr.—this genus is now confined to species with ribbed or polygonal pinkish spores.
angustus Fr.—not known what this refers to.
carneo-albus (With.) Fr.=decurrent form of *Leptonia sericella*.
cancrinus Fr.=*Eccilia cancrina*.
mundulus (Lasch) Fr.=*Clitocybe (Rhodopaxillus) mundula*.
orcella (Bull.) Fr.=*C. prunulus*.
popinalis Fr.=*Clitocybe (Rhodopaxillus) popinalis*.
Sarnicus Mass.—probably decurrent form of *Entoloma ardosiacum*=*Eccilia Mougeotii*.
Smithii Mass.—Cke. Ill. 350 (599) looks like *Laccaria laccata*.
stilbocephalus B. & Br.—identity uncertain; seems to be an *Entoloma*.
straminipes Mass.=*Eccilia straminipes*.
undatus Fr.=*Eccilia undata*.
vilis Fr.=*Eccilia undata* or *E. Mougeotii*.

(Rhodophyllus Quél.)

I. Gen. ENTOLOMA Fr.

Ovisporae

- Entoloma porphyrophaeum* Fr.
jubatum Fr.
dichroum (Pers.) Fr.
excentricum Bres.
erophilum Fr.
griseo-cyaneum Fr.
var. *roseum* Maire
turbidum Fr.

Subsphaerosporae

- Entoloma lividum* (Bull.) Fr.
prunuloides Fr.

- Entoloma nitidum* Quél.
ardosiacum (Bull.) Fr.
var. *Mougeotii* (Quél.)
madidum Fr.
Bloxami B. & Br.
clypeatum (Linn.) Fr.
sericeum (Bull.) Fr.
costatum Fr.
rhodopolium Fr.
nidosum Fr.
ameides B. & Br.
speculum (Fr.) Quél.
nigrocinnamomeum Kalch.

II. Gen. LEPTONIA Fr.

- Leptonia lampropus* Fr.
placida Fr.
anatina (Lasch) Fr.
lappula Fr.
Reaae Maire
aethiops Fr.
solstitialis Fr.
sericella (Fr.) Quél.
var. *decurrens* Boud.
incana Fr.
formosa Fr.

- Leptonia formosa*
var. *suavis* (Lasch) Fr.
Queletii Boud.
chalybaea (Pers.) Fr.
serrulata Fr.
var. *laevipes* Maire
var. *atrises* (Lasch) Kühner & Maire
lazulina Fr.
euchroa (Pers.) Fr.
asprella Fr.
nefrens Fr.
sarcita Fr.

III. Gen. NOLANEA Fr.

- Nolanea stauropora* Bres.
cetrata (Fr.) Schroet.
hirtipes (Schum.) Fr.
mammosa (Linn.) Fr.
papillata Bres.
infula Fr.
junceae Fr.
versatilis Fr.
minuta Karst.

- Nolanea icterina* Fr.
Babingtonii Blox.
fulvo-strigosa B. & Br.
fumosella Winter
coelestina Fr.
exilis Fr.
verecunda Fr.
rufo-carnea Berk.
vinacea (Scop.) Fr.

IV. Gen. *ECCILIA* Fr.

Eccilia cancrina Fr.
carneo-grisea B. & Br.
griseo-rubella (Lasch) Fr.
rhodocylix (Lasch) Fr.
undata (Fr.) Big. & Guill.

Eccilia parkensis Fr.
straminipes (Mass.) comb. nov.
 (See also decurrent forms of *Leptonia*
 and *Entoloma*)

V. Gen. *CLAUDOPUS* W.G.Sm. em. Patouillard

Claudopus depluens (Batsch) Fr. *Claudopus byssisedus* (Pers.) Fr.
 (see *Crepidotus* for *Cl. variabilis*, etc.)

NOTES

- Rhodophyllum* Quél.—some modern authors have adopted this genus to include all the agarics with pink nodulose spores, but the old Friesian sections are still serviceable. Romagnesi has worked out a new grouping largely based on the shape of the spore, which is very impressive but too complex for general use.
- Entoloma Batschianum* Fr.—doubtful British record.
- bulbigenum* B. & Br.—probably *Leptonia sericella*.
- Farrahii* Mass.—has smooth spores, so not an *Entoloma*.
- fertile* Berk. = *E. lividum*.
- helodes* Fr.—not known. Cke. *Ill.* 322 (329) suggests *E. prunuloides*.
- jubatum* Fr.—often confused with *E. porphyrophaeum* which is very common. *E. jubatum* is smaller and has no trace of purple.
- liquescent* Cke. = *Psilocybe sarcocephala* or *P. spadiceo-grisea*.
- majale* Fr.—doubtful British record. *Nolanea majalis* (Fr.) Konr. was renamed *N. hirtipes*.
- nigrocinnamomeum* Kalch.—left in because Massee's figure in Cke. *Ill.* 1158 (1153) is a well-marked agaric difficult to place elsewhere.
- placenta* (Batsch) Fr. = *E. porphyrophaeum* sec. Konr. & Maubl. but Cke. *Ill.* 321 (314) looks like a small *Collybia platyphylla*.
- pluteoides* Fr.—identity uncertain; may be large *Pluteus semi-bulbosus*.
- pulvereum* Rea = *Nolanea fumosella*.
- repandum* Fr.—hardly distinct from *E. prunuloides*.
- resutum* Fr.—doubtful record.
- Rozei* Quél.—doubtful record.
- Saundersii*—from W. G. Smith's figure in Cke. *Ill.* 331 (306) and the spores given by Rea, this is the white form of *Pluteus cervinus* (*patricius*). Boudier has spores 11–13 μ , but his is a different species.
- sinuatum* = *E. lividum*.
- Thomsonii* B. & Br.—position uncertain—doubtful if an *Entoloma* or a *Pluteus*.
- tortipes* Mass.—the description and spores suggest typical *Collybia distorta*.
- venosum* Gillet—probably *E. costatum*.
- Wynnei* B. & Br.—may be *E. griseo-cyaneum*.
- Eccilia acus* W.G.Sm.—an alien on coffee seeds in greenhouse.
- atrides* (Lasch) Fr.—decurrent form of *Leptonia serrulata*.
- atro-puncta* (Pers.) Fr. = *Omphalia atro-puncta*.
- flosculus* W.G.Sm.—an alien in fern house.
- nigrella* (Pers.) Gillet—decurrent form of *Leptonia serrulata*.
- parkensis* Fr.—left in, but not recorded in Britain for many years.
- Leptonia acuta* Rea—an acute form of *Entoloma sericeum*.
- chloropolia* Fr.—probably *Nolanea icterina*.
- euchlora* (Lasch) Fr. = *L. incana*.
- serrulata* var. *Berkeleyi* Maire = *Entoloma ardosiacum*.
- Nolanea araneosa* Quél. = *N. fulvo-strigosa* B. & Br. sec. Bresadola.
- majalis* (Fr.) Konr. = *N. hirtipes*.
- nigripes* (Trog) Fr. = *Naucoria cucumis*.
- pascua* (Pers.) Fr.—a collective species. It was described by Fries in *Syst. Myc. as proteus hujus sectionis quem in decem species distinguere postis*. In Britain it was until recent years applied to a very common *Nolanea* which has been clearly defined by Bresadola under the name *stauropora*, and there seems to be general agreement to accept this.

Nolanea pisciodora (Ces.) Fr.—usually considered as the same as *Naucoria cucumis*, though the epithet has been applied to a genuine *Nolanea*.

proletaria (Fr.) Boud. = *N. staurospora*.

rhodospora Br. & W. G. Sm.—an alien.

rubida Berk.—not a *Nolanea*. Cke. Ill. 367 (340) looks like *Clitopilus cretatus*.

rufo-carnea Berk.—not known. Cke. Ill. 364 (378) is copied from Berkeley's original drawing but so badly reproduced that the plate looks like *Laccaria laccata*, quite unlike the original painting which represents an unfamiliar agaric.

strigossima Rea = *N. fumosella* Winter.

subglobosa A. & S.—Cke. Ill. 1160 (1170) may be *N. icterina* though the smooth spores suggest a *Pluteus*.

Claudopus variabilis and *sphaerosporus*—the genus *Claudopus* is applied by most modern authors only to species with pinkish angular spores. *Cl. variabilis* has smooth spores which are clay-coloured in mass, and it is better to restore it to its original position as a *Crepidotus* together with its round-spored ally.

Gen. PHOLIOTA Fr.

Eu-Pholiota

Pholiota squarrosa (Mull.) Fr.

subsquarrosa (Mull.) Fr.

Mulleri Fr.

aurivella (Batsch) Fr.

grandis Rea

adiposa Fr.

lucifera (Lasch) Fr.

spectabilis Fr.

flammans Fr.

mutabilis (Schaeff.) Fr.

terrigena Fr.

curvipes Fr.

tuberculosa (Schaeff.) Fr.

destruens Brond.

(*Phaeolepiota* Maire)

Pholiota aurea (Mattusch.) Fr.

(*Rozites* Karst.)

Pholiota caperata (Pers.) Fr.

(*Hebeloma* Fr.)

Pholiota radicata (Bull.) Fr.

(*Naucoria* Fr. *Phaeomarasmius* Scherff.)

Pholiota erinacea (Fr.) Quél.

(*Agrocybe* Fayod. *Togaria*

W. G. Sm. em. Romagnesi)

Pholiota praecox (Pers.) Fr.

dura (Bolt.) Fr.

sphaleromorpha (Bull.) Fr.

aegerita Brig.

erebia Fr.

(*Conocybe* Fayod em. Kühner)

Pholiota togularis (Bull.) Fr. non Ricken

blattaria Fr. non Ricken

(*Galerina* Kühner)

Pholiota marginata (Batsch) Fr.

mycenoides Fr.

pumila Fr.

NOTES

Pholiota confragosa Fr.—a little-known species; British records not certain.

cruentatus Cke. & Sm.—the figures in Cke. Ill. 399 (366) may be *Cortinari* (*Inoloma*) *rubicundulus* (Rea) Pearson.

dissimulans B. & Br. = small *P. erebia*.

grandis Rea—said to be not uncommon but not well known. Left in, but doubtful whether different from a large *P. squarrosa*.

heteroclita Fr.—Cke. Ill. 389 (366) = *P. destruens*.

junonia Fr.—Cke. Ill. 397 (369) represents a slender form of *P. spectabilis*.

leochroma Cke. = *P. aegerita*.

molliscorium Cke. & Mass. = *P. erebia*.

muricata Fr.—this species has been referred to *Naucoria*, but we do not know if British record refers to the same agaric.

mustelina Fr.—position uncertain so left out, but Cke. Ill. 404 (356) looks authentic.

ombrophila Fr. = *P. erebia*.

paxillus Fr.—British record doubtful.

Pholiota phalerata Fr.—probably form of *P. caperata*. In any case the British record was due to a mistake.

pudica (Bull.) Fr. = *P. aegerita*.

rufidula Kalch.—may be *Tubaria furfuracea*; no authentic British collection.

sororia Karst.—requires clearer diagnosis.

sublutea (Fl. Dan.) Fr.—not adequately described.

unicolor (Fl. Dan.) Fr.—hardly distinguished from *P. marginata*.

Locellina Gillet = *Acetabularia* Berk.

Alexandri Gillet—recorded as British in error.

acetabulosa (Sow.) Sacc.—doubtful species.

Gen. HEBELOMA Fr.

Indusiata Fr.

Hebeloma fastibile (Pers.) Fr.

versipelle Fr.

mesophaeum (Pers.) Fr.

testaceum (Batsch) Fr.

strophosum Fr.

subcollariatum B. & Br.

Denudata Fr.

Hebeloma sinuosum Fr.

sinapizans (Paul.) Fr.

crustuliniforme (Bull.) Fr.

longicaudum (Pers.) Fr.

elatum (Batsch) Fr.

anthracophilum Maire

sacchariolens Quél.

subsaponaceum Karst.

NOTES

Hebeloma capniocephalum (Bull.) Fr.—uncertain species; Cke. Ill. 462 (419) looks like *H. mesophaeum*. Bresadola interprets Bulliard's species as a *Collybia* but his figures on Pl. 199, *Icon*.

Myc., bear little relation to those of Bulliard.

claviceps Fr.—probably a form of *H. versipelle*.

diffRACTUM Fr. = *H. crustuliniforme*.

firmum Fr.—hardly distinct from *H. testaceum*.

glutinosum (Lindgr.) Fr. = *Flammula lenta*.

ichnostylum Cke. = *H. sacchariolens*.

lugens (Jungh.) Fr.—not known.

magnimamma Fr.—doubtful to what this refers.

mussum Fr.—probably *Cortinarius percomis*. The figures in Fr. *Icon*. III suggest this.

nauseosum Cke.—may be *H. sacchariolens*. The large spores, $20 \times 11 \mu$, are probably wrongly described.

nudipes Fr.—most likely to be *H. longicaudum*.

punctatum Fr.—perhaps a form of *Flammula lenta*.

radicatum (Cke.) Maire—a very uncertain species based on Cke. Ill. 459 (416). Maire thought the figures might be a slender *H. senescens*. Boudier suggested *Flammula lenta*.

senescens (Batsch) B. & Br. = *H. sinuosum*.

sinapizans (Paul.) Fr.—left in but may be the same as *H. sinuosum* or a luxuriant form of *H. crustuliniforme*.

truncatum Schaeff.—usually identified with *Tricholoma* (*Rhodopaxillus*) *truncatum* but Lange maintains that there is a genuine *Hebeloma truncatum*.

Gen. FLAMMULA Fr.

Lubricae Fr.

Flammula lenta (Pers.) Fr.

lubrica (Pers.) Fr.

gummosa (Lasch) Quél.

spumosa Fr.

carbonaria Fr.

scamba (Fr.) Sacc.

Subsiccae Lange

Flammula ochrochlora Fr.

astragalina Fr.

alnicola Fr.

var. *salicicola* Fr.

apicrea Fr.

austera Fr.

Subsiccacae Lange (continued)

(Fulvidula Romagnesi)

Flammula fusus (Batsch) Fr.

Flammula hybrida Fr.

azyma Fr.

limulata Fr.

flavida (Schaeff.) Fr.

liquiritiae (Pers.) Fr.

inaurata W.G.Sm.

sapinea Fr.

conissans Fr.

picrea Fr.

Aldridgei Mass.

flava (Bres.) Lange

clitopila Cke.

decipiens W.G.Sm.

NOTES

Flammula Aldridgei Mass.—left in, but this orange-coloured *Flammula* with the large spores requires confirmation.

carnosa Mass.—needs further elucidation.

clitopila Cke. & Sm.—not known but W. G. Smith's figure in Cke. *Ill.* 468 (500) is so distinct that it is best left in list. Killerman reported it from Bavaria.

decipiens W.G.Sm.—like the last, not well known, but reported by Killerman from Bavaria.

decussata Fr.—no British record of this species.

filia Fr.—not in *Hym. Eur.* Cke. *Ill.* 476 (432) may be a large form of *Cortinarius rubicundulus*.

filicea Cke.—an alien on tree-fern stem.

floccifera B. & Br.—small form of *Flammula lenta*.

gymnopodia (Bull.) Fr. = *Clitocybe tabescens* sec. Quélet, but Cke. *Ill.* 465 (431) is a luxuriant form of *Flammula sapinea* growing on sawdust.

helomorpha Fr. = *Ripartites tricholoma*.

inopus Fr.—no definite British record for this. Cke. *Ill.* 484 (446) is not this species, but

Hypholoma radicosum Lange.

juncina Sm. = *F. lubrica* or form of *F. alnicola*.

lupina Fr.—doubtful record.

mixta Fr.—Cke. *Ill.* 471 (474) = either *F. carbonaria* or *F. lubrica*.

nitens Cke. & Mass.—an ambiguous species. Massee's figure in Cke. *Ill.* 1168 (1154) does not look like a *Flammula*.

penetrans Fr. = *F. sapinea* Fr. *Syst. Myc.*, where Fries cites *penetrans* as a synonym.

purpurata Cke. & Mass.—exotic, on tree fern.

rubicundula Rea = *Cortinarius (Ino.) rubicundulus*.

strigoceph Fr. = *Ripartites tricholoma*.

tricholoma (A. & S.) Fr.—this agaric has been put in many genera and has (we hope) at last found a permanent home in the genus *Ripartites*.

vinosa (Bull.) Fr.—an ambiguous species. Cke. *Ill.* 466 (437) looks rather like *Pleurotus Eryngii*, not yet recorded for Britain.

Gen. NAUCORIA Fr.

(1) *Euagrocye* (Fayod) Heim(3) (*Alnicola* Kühner)

Naucoria semi-orbicularis (Bull.) Fr.

Naucoria escharoides Fr.

pediades Fr.

submelinoides Kühner

vervacti Fr.

var. *alnetorum* Maire

arvalis Fr.

Bohemica Vel.

var. *tuberigena* Quélet.

amarescens Quélet.

tabacina Fr.

(4) (*Macrocytis* Heim)(2) (*Phaeocollybia* Heim)

Naucoria cucumis (Pers.) Fr.

Naucoria lugubris Fr.

(5) (*Galerina* Kühner)

festiva Fr.

Naucoria camerina Fr.

cidaris Fr.

sideroides (Bull.) Fr.

triscopa Fr.

(6) *Eu-naucoria* Heim

(a) *Nudae*

Naucoria centunculus Fr.
cerodes Fr.
horizontalis (Bull.) Fr.
myosotis Fr.
temulenta Fr.

(b) *Vestitae*

Naucoria carpophila Fr.
effugiens Quéf.
siparia Fr.

(7) (*Phaeomarasmius* Scherff.)

Naucoria erinacea Fr.
rimulincola (Lasch) Rabh.

NOTES

Naucoria abstrusa Fr. = *Flammula abstrusa* sec. Lange, but not known if British record refers to the same species.

anguinea Fr. — Cke. *Ill.* 494 (455) appears to be copied from Fries. British record requires confirmation.

badipes Fr. — transferred to *Galera*.

conspersa (Pers.) Fr. — has many interpretations. Lange places it in the *Alnicola* section.

Romagnesi says it is the commonest *Tubaria*.

echinospora W.G.Sm. — possibly a *Leptonia* from the rough spore, but it is an exotic as it grew in greenhouse.

glandiformis Cke. — *Ill.* 500 (490) B is probably a *Cortinarius*.

graminicola (Nees) Fr. — probably *Crinipellis stipitarius*.

hamadryas Fr. — may be *N. arvalis*.

hydrophila Mass. = *Psilocybe semi-lanceata*.

innocua (Lasch) Fr. — Cke. *Ill.* 498 (489) = *Flammula carbonaria*.

latissima Cke. *Ill.* 510 (482) — inadequately described.

melinoides Fr. — what is usually called by this name in Britain is *Galera mniophila*.

nasuta Kalch. — Cke. *Ill.* 1173 (1172) = *Psilocybe semi-lanceata*.

nucea (Bolt.) Fr. — not known. Bolton's figure in Cke. *Ill.* 500 (490) suggests a form of *Psathyrella crenata*.

obtusata Cke. & Mass. — probably *Psilocybe sarcocephala*.

porriginosa Fr. — Cke. *Ill.* 511 (510) may be a form of *Tubaria furfuracea* or *Cortinarius scandens*.

pusiolo Fr. — possibly *Tubaria crobulus*.

reducta Fr. — best left out for further investigation; often confused with *N. centunculus*.

rubricata B. & Br. = *Marasmius ramealis*.

scolecina Fr. — not really known; appears to belong to the *Alnicola* group.

scorpioides Fr. — recorded by Plowright, but there is some doubt what species it refers to.

N. scorpioides sensu Lange = *N. Bohemica*.

semiflexa B. & Br. — may be *Tubaria crobulus*.

semi-orbicularis (Bull.) Fr. — left in list but considered by many authors to be the same as *N. pediades* which would have priority.

sobria Fr. — probably a *Tubaria*.

striaeipes Cke. = *Galera pygmeo-affinis* sec. Kühner.

subglobosa (A. & S.) Fr. = *N. semi-orbicularis* sec. Quélet, but Ricken describes something quite different.

subtemulenta Lamb. — inadequate diagnosis.

tenax Fr. — identity doubtful. Cke. *Ill.* 504 (617) is like a *Tubaria* and so is Ricken's interpretation with its 4-angled heart-shaped spore $5-6 \times 4-5 \mu$. Rea describes a species growing in bogs on the stems of *Potentilla Comarum* and with spore $13-16 \times 7-8 \mu$. This must be *Naucoria myosotis*.

Wieslandrii Fr. — description inadequate.

Gen. TUBARIA Gillet

Tubaria furfuracea (Pers.) Gillet
pellucida (Bull. ex. Fr.) Gillet
trigonophylla (Lasch ex Fr.) Cke.
anthracophila Karst.
autochtona (B. & Br.) Sacc.

Tubaria crobulus (Fr.) Karst.
inquilina (Fr.) Gillet
 (*Galerina* Kühner)
Tubaria paludosa (Fr.) Karst.
stagnina (Fr.) Gillet

NOTES

- Tubaria cupularis* (Bull.) Fr. = *Lactarius* sec. Quélet and Bresadola, but Cke. *Ill.* 526 (602)
 = *T. pellucida* or *T. furfuracea*.
embola Fr.—best left out till British specimens are more clearly defined.
muscorum (Hoffm.) Fr.—unknown.
pellucida (Bull.) Fr.—this common species is left in, but it is questionable whether it differs from *T. furfuracea*.

Gen. GALERA Fr.

- (*Conocybe* Fayod)
Galera spicula (Lasch) Fr.
tenera (Schaeff.) Fr.
antipus (Lasch) Fr.
pilosella (Pers.) Fr.
siliginea Fr.
lactea Lange
pygmaeo-affinis Fr.
Mairei Kühner
plicatella Peck

Galera appendiculata Lange & Kühner
campanulata Mass.

(*Galerina* Earle)

- Galera graminea* Vel.
sphagnorum (Pers.) Fr.
mycenopsis Fr. sensu Ricken
mniophila (Lasch) Fr.
Hypnorum (Batsch) Fr.
rubiginosa (Pers.) Fr.
nana (Petri) Kühner

NOTES

- Galera apala* Fr.—a much disputed species. See note on *G. lateritia*.
campanulata Mass.—not known, but its strong smell and subfusoid spores are distinct characters, so it is not withdrawn. Massee cites Cooke's figures 1174 (1156) for this species.
conferta (Bolt.) Fr. = *G. antipus*.
flexipes Karst.—unknown.
lateritia Fr.—by many authors, including Cooke, Ricken and Kühner, this epithet is used for a white or cream-coloured *Galera* with a bulbous base. The Friesian species refers to a species with a brick-coloured cap. Lange produced a new name for it, *G. lactea*, which we have adopted. It appears to be identical with *Bolbitius tener* Berk. But for its large size *Galera apala* Fr. would be the correct epithet, as the description fits closely.
minuta Quél.—not known.
mycenopsis Fr.—not known as described by Fries, and generally adopted for a fairly common *Galera* as described under this name by Ricken.
ovalis Fr.—some authors depict this as a large form of *G. tenera*, but the *G. ovalis* of Fries has a fugacious ring and is not clearly defined.
pityria Fr.—cannot trace a British record.
ravida Fr.—Cke. *Ill.* 525 (467) might be *Pluteolus aleuriatus*.
Sahléri Quél.—seems little more than a form of *G. hypnorum* with conical pileus.
spartea Fr.—seems to be a form of *G. tenera*.
vestita Fr.—was reported by Bucknall in 1881, but it is doubtful if it corresponds to modern views of the species.
vittaeformis Fr. = *G. rubiginosa* sec. Kühner.

Gen. CREPIDOTUS Fr.

- Crepidotus mollis* (Schaeff.) Fr.
calolepis Fr.
alveolus (Lasch) Fr.
applanatus (Pers.) Fr.
fragilis Joss.

Crepidotus variabilis (Pers.) Fr.
sphaerosporus (Pat.) Lange

(*Phyllotopsis* Gilbert & Donk)

Crepidotus nidulans (Pers.) Quél.

Gen. BOLBITIUS Fr.

- Bolbitius vitellinus* (Pers.) Fr.
fragilis (Linn.) Fr.

Bolbitius titubans (Bull.) Fr.

NOTES

- Crepidotus chimonophilus* B. & Br.—hardly different from *C. variabilis*.
epibryus Fr.—if this differs from *C. variabilis* it requires clearer definition.
epigaeus (Pers.) B. & Br.—Berkeley's figure in Cke. Ill. 537 (516) indicates nodulose spores and may be a species of *Claudopus*.
haustellaris Fr.—Cke. Ill. 536 (575) is from foreign specimens. The two old British records require confirmation.
luteolus Lamb.—no authentic British record.
Parisotii Pat.—British record appears to be a mistake.
pezizoides (Nees) Fr.—diagnosis inadequate.
Phillipsii B. & Br.—probably old *C. variabilis*.
proboscideus Fr.—inadequately described.
putrigenus B. & Curt.—an American species probably listed in error.
Ralfsii B. & Br.—may be form of *C. calolepis*.
Rubi B. & Br. = *Naucoria effugiens*.
versutus Peck—doubtful record.
Bolbitius affinis Mass.—not known, but may be *Galera lateritia* Fr.; more clearly defined in *G. lactea* Lange.
apicalis W. G. Sm.—doubtful if a *Bolbitius* or a *Galera*.
Boltonii (Pers.) Fr. = *B. vitellinus*.
bulbillosus Fr.—a doubtful species reported from Scotland.
flavidus (Bolt.) Mass. = *B. vitellinus*.
fragilis (Linn.) Fr.—left in but hardly distinct from *B. vitellinus*.
grandiusculus Cke. & Mass. = large form *B. vitellinus*.
niveus Mass.—from a palm house. May be *Galera apala*.
rivulosus B. & Br.—in orchid house but probably only a form of *B. vitellinus*.
tener Berk. = *Galera lactea*.
titubans (Bull.) Fr.—left in but doubtful if different from *B. vitellinus*.

Gen. CORTINARIUS Fr.

(Myxaciium Fr.)

- Cortinarius mucosus* (Bull.) Fr.
collinitus (Pers.) Fr.
stillatitius Fr.
elator Fr.
salor Fr.
delibutus Fr.
illibatus Fr.
vibratilis Fr.
pluvius Fr.
epipolius Fr.
croceo-caeruleus Fr.
livido-ochraceus Berk.

(Phlegmacium Fr.)

A. Scauri Fr.

- Cortinarius multiformis* Fr.
rapaceus Fr.
intermedius Rea
napus Fr.
allutus (Secr.) Fr.
purpurascens Fr.
var. subpurpurascens Fr.
caerulescens (Schaeff.) Fr.

Cortinarius caesiocyanus Britz.

- dibaphus* Fr.
var. xanthophyllus Cke.
glaucopus (Schaeff.) Fr.
herpeticus Fr.
cyanopus (Secr.) Fr.
calochrous (Pers.) Fr.
fulgens (A. & S.) Fr.
fulmineus Fr.
elegantior Fr.
flavescens (Cke.) Henry
turbinatus (Bull.) Fr.
lutescens (Rea) Henry
prasinus (Schaeff.) Fr.
atro-virens (Kalch.) Fr.
orichalceus (Batsch) Fr.
rufo-olivaceus (Pers.) Fr.
scaurus Fr.

B. Cliduchi Fr.

- Cortinarius sebaceus* Fr.
claricolor Fr.
triumphans Fr.
praestans (Cordier) Sacc.
balteatus Fr.

Cliduchi Fr. (continued)

Cortinarius largus Fr.
 var. *nemorensis* Fr.
variicolor (Pers.) Fr.
varius (Schaeff.) Fr.
cumatilis Fr.
infractus (Pers.) Fr.
percomis Fr.
Riederi (Weinm.) Fr.
saginus Fr.

C. Elastici Fr.

Cortinarius turmalis Fr.
crystallinus Fr.
causticus Fr.
emollitus Fr.
decolorans Fr.
decoloratus Fr.
porphyropus (A. & S.) Fr.
 (croceo-caeruleus Fr.); see *Myxaciium*
papulosus Fr.

(Inoloma Fr.)

Cortinarius humicola (Quél.) Maire
opimus Fr.
turgidus Fr.
argutus Fr.
pholideus Fr.
tophaceus Fr. non Quél.
Bulliardii (Pers.) Fr.
bolaris (Pers.) Fr.
rubicundulus (Rea) Pearson
violaceus Fr.
albo-violaceus (Pers.) Fr.
suillus Fr.
argentatus (Pers.) Fr.
fusco-tinctus Rea
cyanites Fr.
muricinus Fr.
hircinus Fr.
traganus Fr.
 var. *finitimus* Weinm.
vinosus Cke.
 (*C. malachius* Fr., see *Telamonia*)

(Dermocybe Fr.)*A. Ochroleuci* Konr. & Maubl.

Cortinarius ochroleucus (Schaeff.) Fr.
decumbens (Pers.) Fr.
camurus Fr.
tabularis (Bull.) Fr.

B. Cinnamomei Konr. & Maubl.

Cortinarius cinnamomeus Fr.
croceo-conus Fr.

Cortinarius semi-sanguineus Gillet
sanguineus (Wulf.) Fr.
malicorius Fr.
cinnabarinus Fr.
anthracinus Fr. non Quél.
uliginosus Berk.
Queletii Bat.
phoeniceus (Bull.) Maire
orellanus Fr. non Quél.

C. Anomali Konr. & Maubl.

Cortinarius anomalus Fr.
lepidopus Cke.
azureus Fr.
caninus Fr.
myrtilinus Fr.
spilomeus Fr.

D. Veneti Konr. & Maubl.

Cortinarius cotoneus Fr.
venetus Fr.
raphanoides (Pers.) Fr.

(Telamonia Fr.)*A. Platyphylli* Fr.

Cortinarius macropus Fr.
laniger Fr.
bivelus Fr.
licinipes Fr.
bulbosus (Sow.) Fr.
malachius (Fr.) Pearson
bovinus (Secr.) Fr.
triformis Fr.
glandicolor Fr.
brunneus (Pers.) Fr.
biformis Fr.
brunneo-fulvus Fr.
armillatus Fr.
limonius Fr.
callisteus Fr.
helvolus Fr.
hinnuleus Fr.
gentilis Fr.
nitrosus Cke.
helvelloides Fr.
penicillatus Fr.
torvus Fr. non Quél.
scutulatus Fr.
impennis Fr.
evernius Fr.
quadricolor Fr.
plumiger Fr.

B. *Leptophylli* Fr.

Cortinarius paleaceus Fr.
flexipes Fr.
hemitrichus (Pers.) Fr.
rigidus (Scop.) Fr.
stemmaus (Fr.) Ricken
iliopodius (Bull.) Fr.
incisus (Pers.) Fr.
Cookei Quél.
psammocephalus (Bull.) Fr.
flabellus Fr.
Iris Mass.
ammophilus Pearson

(*Hydrocybe* Fr.)

A. *Firmiores* Fr.

Cortinarius duracinus Fr.
pseudo-duracinus Henry
subferrugineus (Batsch) Fr.
imbutus Fr.
firmus Fr.
armeniacus Fr.
damascenus Fr.
dilutus Fr.
tortuosus Fr.

Cortinarius saturninus Fr.
bicolor Fr.
castaneus (Bull.) Fr.
balaustinus Fr.
colus Fr.
isabellinus (Batsch) Fr.
renidens Fr.
uraceus Fr.
pateriformis Fr.
rubricosus Fr. sensu Lange
holophaeus Lange

B. *Tenuiores* Fr.

Cortinarius rigens Fr.
leucopus (Bull.) Fr.
Krombholzii Fr.
obtusius Fr.
scandens Fr.
acutus (Pers.) Fr.
erythrinus Fr.
decipiens (Pers.) Fr.
germanus Fr.
saniosus Fr.
fasciatus Fr.
Junghuhnii Fr.

NOTES

Cortinarius albo-cyanus Fr.—not known.
angulosus Fr.—variously interpreted. Cke. III. 1192 (1178) may be a form of *C. cinnamomeus* or *C. venetus*.
arenatus Fr. non Quél. = *C. pholideus*.
arvinaceus Fr. = *C. mucosus*.
camphoratus Fr.—doubtful record; not the same as that of Ricken or Henry; Cke. III. 751 (771) is probably *C. hircinus* or *C. traganus*.
coruscans Fr.—not known. Cke. III. 730 (733) may be *C. sebaceus*.
colymbadinus Fr.—record doubtful.
corrosus Fr.—Cke. III. 715 (715) looks like a dwarf form of *C. multiformis*.
croceo-fulvus (DC.) Fr.—Cke. III. 1191 (1193) suggests *C. callisteus*.
crassus Fr.—has several interpretations. Cke. III. 685 (695) is more like *C. praestans*.
dolobratius Quél.—hardly seems distinct from *C. triumphans*.
depressus Fr.—doubtful. Cke. III. 854 (860) looks like *C. duracinus*.
detonsus Fr.—record by Stevenson not this species.
diabolicus Fr.—Cke. III. 765 (816) looks like *C. rigens*.
dolobratius Fr.—not known what this is. Cke. III. 845 (811) has been referred to several species.
duracinus Fr.—Henry has established a new species *C. pseudo-duracinus* now included in British list since it is based on Cooke and Massee's spore measurements $5 \times 3 \mu$. Henry's measurements are $5-5\frac{1}{2} \times 4\frac{1}{2}-5 \mu$, so it is extremely doubtful if the two species are identical.
fallax Quél.—no British record can be traced.
fulvescens Fr.—no British record can be traced.
grallipes Fr.—Cke. III. 738 (734) by W. G. Smith looks like a large *Flammula gunmosa*. The true *grallipes* has a prominent acute umbo.
ianthipes—not known.
illuminus Fr.—hardly known. Cke. III. 830 (841) suggests *C. rubicundulus*.
impennis Fr. var. *lucorum* Fr.—record is based on Cke. III. 1190 (1192) which looks more like *C. evernius*.

Continarius infucatus Fr.—awaits more detailed description.

injucundus (Weinm.) Fr.—Cke. *Ill.* 809 (823) is old *C. largus*.

Iris Mass.—rather dubious, but not withdrawn.

irregularis Fr.—based on old record by Bolton which from original description and figure was

Volvaria speciosa f. *gloiocephala* with remnant of volva.

jubarinus Fr.—doubtful if distinct from *C. cinnamomeus*.

latus (Pers.) Fr.—cannot trace British record.

licinipes Fr.—left in because of Cke. *Ill.* 792 (819) which may however be a form of *C. bivelus*.

livido-ochraceus Berk.—left in with some doubt because the flesh is mild; otherwise W. G.

Smith's figures in Cke. *Ill.* 739 (767) look like pale forms of *C. croceo-caeruleus*.

lustratus Fr.—Cke. *Ill.* 688 (799) may be *C. argentatus*.

microcylus Fr.—unknown species. Cke. *Ill.* 793 (865) = *C. glandicolor*.

milvinus Fr.—seems identical with *C. raphanoides*.

mucifusus Fr.—Cke. *Ill.* 735 (740) is typical *C. collinitus*. Most authors describe a form of *C. elatior* under this name.

nitidus (Schaeff.) Fr.—based on Cke. *Ill.* 1189 (1191) which may be *C. delibutus*.

olivascens (Batsch) Fr.—remains to be seen if the British record is other than *C. infractus*.

paragaudis Fr.—doubtful.

periscelis Fr. = *C. paleaceus*.

phrygianus Fr.—fuller description needed.

plumiger Fr.—doubtful if British record refers to this very rare species.

privignus Fr.—requires further investigation; at present it seems much the same as *C. ochroleucus*.

punctatus (Pers.) Fr.—doubtful record.

quadricolor (Scop.) Fr.—left in because of the excellent figure in Cke. *Ill.* 799 (867) but rather dubious.

Reedii Berk.—not known what this refers to. Cke. *Ill.* 848 (843) looks like an *Inocybe*.

riculatus Fr.—doubtful.

Riederi Fr.—uncertain, but left in because of Epping record and Cooke's excellent figures, 694 (702).

rubellus Cke. = *C. orellanus* Fr.

russus Fr.—doubtful. Cke. *Ill.* 696 (751) looks more like *C. sub-ferrugineus*.

sciophyllus Fr.—doubtful if distinct from *C. saturninus*.

serarius Fr.—record doubtful.

sublanatus Sow. = *C. pholideus*. Cke. *Ill.* 761 (762) is also *pholideus*. The *C. sublanatus* of other authors is *C. cotoneus*.

subnotatus Fr. = *raphanoides* or *venetus*.

testaceus Cke. = *C. rufo-olivaceus*.

turbinatus var. *lutescens* Rea = *C. lutescens* (Rea) Henry.

unimodus Britz.—Cke. *Ill.* 844 (859) = *C. erythrinus*.

urbicus Fr.—record uncertain.

valgus Fr.—unknown species. Cke. *Ill.* 785 (750) may be *C. raphanoides* or *C. venetus*.

vespertinus Fr.—not a convincing record.

vinosus Cke.—has been queried. Cke. *Ill.* 758 (759) looks rather like *C. subpurpurascens* but the spores are different and it may well be a distinct species.

violaceo-fuscus Cke. & Mass. = *Inocybe obscura*.

Gen. INOCYBE Fr.

I. *Levisporae*

(a) *Depauperata*

Inocybe rhodiola Bres.

Patouillardii Bres.

Bongardii (Weinm.) Quél.

cervicolor (Pers.) Karst.

calamistrata Fr.

hirsuta Lasch

Inocybe relicina Fr.

fastigiata (Schaeff.) Fr.

Cookei Bres.

maculata Boud.

perlata (Weinm.) Fr.

perbrevis Fr. sensu Cke.

dulcamara (A. & S.) Fr.

squamata Lange

(b) *Muriculatae*

Inocybe pyriodora (Pers.) Fr.
 var. *incarnata* (Bres.) Maire
corydalina Quél.
lucifuga Karst.
haemacta Berk. & Cke.
 var. *rubra* Rea
Godeyi Gillet
hystrix Fr.
mutica Fr. sensu Cke.
cinninata Fr.
obscura (Pers.) Fr.
griseo-lilacina Lange
geophylla (Sow.) Fr.
 var. *lilacina* Fr.
vaticosa Fr.
flocculosa Berk.
abjecta Karst.
eutheles B. & Br.
pallidipes Ell. & Ev.
descissa Fr.
 var. *brunneo-atra* Heim
auricoma (Batsch) Fr.
deglubens Fr.
posterula (Britz.) Lange
Queletii Maire & Konr.
sambucina Fr.
brunnea Quél.
lacera Fr.
halophila Heim
serotina Peck

II. *Nodulisporae*

(Astrosporina Schroet.)

Inocybe asterospora Quél.
napipes Lange
umbrina Bres.
striata Bres.
margaritispora Berk.
umboninata Peck
trechispora Berk.
grammata Quél.
fulva Rea
fibrosa Sow.
duriuscula Rea
praetervisa Quél.
scabella Fr. sensu Cke.
fulvella Bres.
Boltonii Heim
lanuginella Schroet.
decipientoides Peck
lanuginosa (Bull.) Fr.
longicystis Atk.
umbratica Quél.
maritima Fr.
fasciata Cke. & Mass.
Rennyi B. & Br.
petiginosa (Fr.) Gillet

III. *Verrucosisporae**Inocybe calospora* Quél.

NOTES

Inocybe abjecta Fr.—left in, but doubtful if other than a small form of *I. flocculosa*.
Bresadolae Mass. = *I. grammata* Quél.
Bucknallii Mass. = *Nolanea fumosella*.
caesariata Fr.—Cke. Ill. 437 (388) probably *I. hirsuta*.
carpta (Scop.) Fr.—has different interpretations. Cke. Ill. 419 (426) is probably *I. hirsuta*, while Bres. Icon. 756 has nodulose spores.
Clarkii B. & Br. = *I. geophylla*.
conformata Karst.—seems to conform to *I. obscura*.
districta Fr.—not clearly defined; may be *I. jurana* Pat. which, though near to *I. rhodiola*, does not turn the rich claret colour so characteristic of the latter. But the synonymy of these two species is uncertain.
duriuscula Rea—left in, though Kühner thinks it a form of *I. grammata*.
fasciata Cke. & Mass.—retained but not known since first found in Kew Gardens; may be an exotic.
Gailliardi Gillet = *I. calospora*.
infida Peck = *I. umbratica* Quél.
mamillaris Pass.—description insufficient.
margaritispora Berk.—not known to modern mycologists but from Cke. Ill. 432 (505) it appears to be a distinct species, unless considered as a large form of *I. calospora*.
mimica Mass.—probably *I. lacera*.
mutica Fr.—not really known but Cke. Ill. 418 (382) appears to represent a distinctive thing and the name is retained.

Inocybe nigro-disca Peck—record doubtful.

phaeocephala Cke.—the bright ferruginous spores indicate a *Cortinarius*.

perbrevis (Weinm.) Fr.—left in since Heim accepts it on basis of Cke. *Ill.* 434 (519) though this plate does not look a bit like an *Inocybe*.

plumosa Bolt.—doubtful if an *Inocybe*. The *I. plumosa* of Konr. & Maubl. is *I. lanuginosa*.

proximella Karst. = *I. asterospora*.

pseudo-fastigiata Rea = *I. fastigiata*.

Rennyi B. & Br.—left in with some doubt. Heim examined type specimen, and accepts species.

rimosa (Bull.) Fr.—this epithet has been applied to many different species and has been abandoned. The *rimosa* of Fries was probably *I. asterospora*; the description in *Syst. Myc.* certainly suggests this.

Sabuletorum B. & Curt. = *I. lanuginosa*.

scabra (Mull.) Fr.—epithet used in different senses; uncertain what British record refers to.

Cke. *Ill.* 413 (391) is cited by Heim as near *I. splendens*.

schista Cke. & Sm.—description inadequate. Cke. *Ill.* 423 (504) looks more like a *Cortinarius*.

sindonia Fr.—hardly distinct from *I. geophylla*.

squarrosa Rea = *I. cinnamata*.

Trinii Weinm.—uncertain what this refers to; may be a small form of *I. Patouillardii*.

tomentosa Quél. (1888) = *I. eutheles* B. & Br. (1865). The *I. tomentosa* of Junghuhn (1830) is doubtful and has nothing to connect it with *I. eutheles*.

vatricosa Fr.—not well known; usually on wood and retained for this reason but clearer definition needed.

violaceo-folia Peck = a *Cortinarius* sec. Heim.

Whitei B. & Br. = *I. vatricosa* Fr. sec. Heim.

Gen. PAXILLUS Fr.

Paxillus involutus (Batsch) Fr.

(*Tapinella* Gilbert)

atrotomentosus (Batsch) Fr.

Paxillus panuoides Fr.

(See also *Phylloporus* among the Boletales)

NOTES

Paxillus Alexandrii Fr. = *Clitocybe Alexandrii* (Gillet) Konrad, but there is no clear British record.

The following extract from a letter written by G. Massee to A. A. Pearson, dated 19 Jan. 1916, disposes of one record: 'Cooke and I were responsible for the record, but in reality it was founded on a small specimen of the old *Lactarius exsuccus*.'

crassus Fr.—Cke. *Ill.* 864 (861) is probably old *Phylloporus rhodoxanthus*.

extenuatus Fr.—Cke. *Ill.* 863 (873) looks like *Clitocybe amara*.

giganteus (Sow.) Fr. = *Clitocybe gigantea*.

lepista Fr.—has different meanings; sensu Ricken it is *Clitocybe* (*Rhodoxanthus*) *mundula*; sensu

Cooke it may be *Clitocybe amara*.

leptopus Fr.—said to be confined to alders, but hardly distinct from *P. involutus*.

lividus Cke.—probably *Tricholoma cinerascens*.

orcelloides Cke. & Mass.—may be *Clitocybe fallax*.

panaeolus Fr. = *Ripartites tricholoma*.

paradoxus (Kalch.) Quél. = *Phylloporus rhodoxanthus*.

porosus Berk.—probably *Phylloporus rhodoxanthus*.

revolutus Cke.—Cooke's figure 865 (862) looks like *Hygrophorus cinereus* but round spores, if correct, would not fit.

Gen. STROPHARIA Fr.

I. *Mundae* Fr.

Stropharia coronilla (Bull.) Fr.

Stropharia aeruginosa (Curtis) Fr.

hypsipus Fr. sensu Lange

albo-cyanea (Desm.) Fr.

melanosperma (Bull.) Quél.

Worthingtonii Fr.

squamosa (Pers.) Fr.

inuncta Fr.

var. *thrausta* Kalch.

luteonitens (Vahl) Fr.

II. *Merdariae* Fr.

Stropharia semi-globata (Batsch) Fr.
merdaria Fr.

III. *Hypholomoideae*

Stropharia caput-Medusae Fr.
scobinacea Fr.
Jerdonii B. & Br.

Stropharia spintrigera Fr.
Hornemannii Fr.
Percevalii B. & Br.
Ferrii Bres.

IV. *Psathyroideae* Lange

Stropharia psathyroides Lange
(See also *Anellaria* and *Psathyra pennata*)

NOTES

Stropharia Batarrae Fr.—no British collection can be traced; it is a problematical species.

coturnata Fr.—description inadequate.

depilata (Pers.) Fr. = *S. Hornemannii* Fr. *Syst. Myc.*

hypsipus Fr.—Massee's figure in *Cke. Ill.* 571 (619) is problematical, but *S. hypsipus* Fr. sensu Lange has been collected and is retained in list.

luteo-nitens (Vahl) Fr.—left in, but it is doubtful if *Cke. Ill.* 564 (604) represents this species.

melasperma (Bull.) Fr. = *melanosperma* sec. Bulliard's spelling.

obturata Fr. = *S. coronilla*.

Percevalii B. & Br.—left in list though much like *Hornemannii* except that spores are much larger sec. *Cke. Ill.* 554 (550).

punctulata (Kalch.) Fr.—a problematical species.

rugoso-annulata Farlow (1929). This has now been identified with *S. Ferrii* Bres. (1928), a species first found in northern Italy and recently reported from Switzerland. The descriptions do not exactly tally, but in view of the remarkable variability observed in the British specimens, we must conclude that they represent the same species.

squamulosa Mass. = *S. aeruginosa*.

stercoraria Fr. = *S. semi-globata*.

versicolor (With.) Fr.—insufficiently described.

Gen. *HYPHOLOMA* Fr.

(*Nematoloma* Karst.)

Hypholoma fasciculare (Huds.) Fr.
sublateritium Fr.
var. *squamosum* Cke.
capnoides Fr.
radicosum Lange
dispersum Fr.

Hypholoma Candolleum Fr.
cascum Fr.
chondrodermum (B. & Br.) Lange
leucotephrum B. & Br.
lacrymabundum Fr. non Bull.

(*Lacrimaria* Pat.)

(*Drosophila* Qué.)

Hypholoma hydrophilum (Bull.) Fr.
catarium Fr. sensu Cke.

Hypholoma velutinum (Pers.) Fr.
pyrotrichum (Holmsk.) Fr.

NOTES

Hypholoma aellopum Fr.—description inadequate.

appendiculatum Fr.—an ambiguous species. The agaric usually given this name is *H. Candolleum*.

catarium Fr.—retained but may only be small *H. hydrophilum*.

egenulum B. & Br. = *H. Candolleum*.

elaeodes Fr. = *H. fasciculare*.

epixanthum Fr.—probably a form of *H. capnoides* sec. Seth Lundell. The British records usually refer to young specimens of *H. fasciculare*.

incomptum Mass.—probably *Stropharia Hornemannii*.

instratum Britz. = *H. chondrodermum*.

irroratum Karst.—doubtful, but suggests *H. radicosum*.

lanaripes Cke. = *H. Candolleum*.

melantinum Fr. = *Stropharia scobinacea* Fr. sensu Ricken.

oedipus Cke.—not known, but *Cke. Ill.* 579 (587) showing a glutinous dark-coloured agaric is characteristic enough to keep in list.

silaceum (Pers.) Fr.—not sufficiently described.

Gen. **PSILOCYBE** Fr.

(Drosophila Quél.)

(Deconica W.G.Sm.)

Psilocybe sarcocephala Fr.*Psilocybe coprophila* (Bull.) Fr.

spadicea Fr.

bullacea (Bull.) Fr.

ammophila Mont.

physaloides (Bull.) Lasch

clivensis B. & Br.

atrorufa (Schaeff.) Fr.

cernua (Vahl) Fr.

cyanescens Wakef.

canofaciens Cke.

(Panaeolina Maire)

catervata Mass.

(Hypholoma Fr. em. Kühner)

Psilocybe foenisecii (Pers.) Fr.

(Nematoloma Karst.)

Psilocybe ericaea (Pers.) Fr.

Anomali

sub-ericaea Fr.

Psilocybe semi-lanceata Fr.

uda (Pers.) Fr.

var. caerulea Cke.

Polytrichi Fr.

elongata Fr.

NOTES

- Psilocybe agraria* Fr.—description incomplete. Cke. *Ill.* 597 (622) looks like a *Mycena*.
areolata (Klotsch) Berk.—Cke. *Ill.* 596 (570) may be a sundried *Hypholoma capnoides*. Cke. *Ill.* 1182 (1177) also was given this name but Massee referred it to *P. virescens*.
atro-brunnea (Lasch) Fr.—identity uncertain and no British record known.
callosa Fr.—has many interpretations.
canobrunnea (Batsch) Fr.—identity of British record uncertain.
canofaciens Cke.—left in, but not known to modern authors.
catervata Mass.—not known but left in, as it is fully described.
chondroderma B. & Br. = *Hypholoma chondroderma*.
compta Fr.—Cke. *Ill.* 603 (589) is probably a *Galera*.
cyanescens Wakefield (1946)—published in these *Transactions*, xxix, 141. In a footnote on p. 165 it was pointed out, that it might prove to be the same as *Hypholoma cyanescens* Maire (1928) as further described and figured by Malençon in 1942. Comparison with the unpublished drawings of Miss Wakefield shows marked differences. The shape of the pileus is very different; so is the attachment of the gills. For the present they are best considered as distinct species.
hebes Fr.—best withdrawn till further elucidated.
helvola (Schaeff.) Mass.—seems to be a *Panaeolus*.
nemophila Fr.—inadequately described and no British record found.
nuciseda Fr.—Cke. *Ill.* 601 (609) is a *Tubaria*.
sarcocephala Fr. var. *Cookei* Sacc. = large form of *P. spadicea*.
scobicola B. & Br.—Cke. *Ill.* 598 (607) looks like *Hypholoma Candolleianum*.
squalens Fr.—not known; description insufficient.
regularis (Schum.) Fr.—not known; and no British record found.
virescens (Cke. & Mass.) Mass.—referred to Cke. *Ill.* 1182 (1177) over the name *P. areolata*; all very doubtful.

Gen. **PSATHYRELLA** Fr. (*Drosophila* Quél.)I. (*Psathyra* Fr.) *Pannucia* Karst.

Veil evident

Psathyrella Gordonii (B. & Br.) comb. nov.

gossypina (Bull. ex Fr.) comb. nov.

fibrillosa (Pers. ex Fr.) comb. nov.

bifrons (Berk.) A. H. Smith

semi-vestita (Berk.) A. H. Smith

pennata (Fr.) comb. nov.

Psathyrella pennata f. *annulata* Pearson

nolitangere (Fr.) comb. nov.

frustulenta (Fr.) A. H. Smith

II. *Eu-Psathyra* Lange

Margin naked. Spores small

Psathyrella spadicea-grisea (Schaeff. ex Fr.)

A. H. Smith

obtusata (Fr. sensu Lange) A. H. Smith

III. *Psathyrella* Fr.*Margin naked. Spores large**Psathyrella caudata* Fr.*conopileia* Fr.*subatrata* (Batsch) Fr.*gracilis* Fr.var. *corrugis* (Pers.) Lange*Psathyrella prona* Fr.*atomata* Fr.*typhae* Kalch.*crenata* LaschIV. (*Pseudocoprinus* Kühner)*Psathyrella disseminata* (Pers.) Fr.*hiascens* Fr.

NOTES

Psathyra Fr.—This generic epithet is withdrawn because it is preoccupied by a genus of flowering plants, as pointed out by Kühner in *Bull. Soc. mycol. Fr.* LII, 11. There being no clear line of demarcation, it is desirable to combine in one genus the species that hitherto have been divided between *Psathyra* and *Psathyrella*; the latter epithet can be adopted, though some authors wish to adopt *Drosophila* Quél.

Psathyra elata Mass. = *Psathyrella conopileia*.

fatua Fr.—it is not clear what this refers to and is best left out for clearer diagnosis.

glareosa B. & Br.—Cke. *Ill.* 610 (591) looks like *Mycena zephira*.

gyroflexa Fr.—wants clearer definition. Cke. *Ill.* 1184 (970) is more like *P. hiascens*.

helobia Kalch.—doubtful record.

Lascosii Rabenh.—description insufficient.

mastigera B. & Br.—hardly distinct from *Psathyrella caudata*.

microrrhiza (Lasch) Fr.—Cke. *Ill.* 622 (596) is *Psathyrella caudata*.

neglecta Mass.—still neglected and unknown.

pellosperma (Bull.) B. & Br.—definition incomplete.

tenuicula Karst.—identity doubtful.

Psathyrella arata Berk.—Cke. *Ill.* 637 (636) is hardly distinct from *conopileia* though unusually sulcate.

emphyreumatica B. & Br.—description inadequate.

hiascens Fr.—referred to *Coprinus* by some authors but the gills do not deliquesce. It is questionable whether it is distinct from *P. impatiens* Fr.

hydrophora (Bull.) Fr.—doubtful.

trepida Fr.—not certain to what the British record refers.

Gen. PANAEOLUS Fr.

(a) *Appendiculati**Panaeolus papilionaceus* (Bull.) Fr.*retirugis* Fr.*campanulatus* (Linn.) Fr.var. *sphinctrinus* (Fr.) Bres.(b) *Nudi**Panaeolus acuminatus* (Schaeff.) Fr.*fimicola* Fr.*subbalteatus* B. & Br.

Gen. ANELLARIA Karst.

Anellaria semi-ovata (Sow. ex Fr.)
comb. nov.*Anellaria fimiputris* (Fr.) Karst.

NOTES

Panaeolus caliginosus (Jungh.) Fr. = *P. acuminatus*.

egregius Mass.—Cke. *Ill.* 624 (624) may be *Hypholoma velutinum* or *H. pyrotrichum*.

leucophanes B. & Br. Cke. *Ill.* 625 (927) is probably a form of *Anellaria semi-ovata*. Ricken describes a different species under this name.

phalaenarum Fr. = *Anellaria semi-ovata* without ring.

Anellaria separata (Linn.) Karst. = *A. semi-ovata*. In the *Syst. Myc.* this appears in the section *Coprinarius* as *Agaricus semi-ovatus*, although *A. separatus* Linn. is given as a synonym. Subsequently Fries adopted the Linnaean name, but by the rules we cannot avoid using *semi-ovata*. The *Agaricus semi-ovatus* on Pl. 131 of Sowerby is clearly this species.

scitula Mass.—a small species of *Coprinus* with a peronate ring. As it was growing in a pot it was probably an exotic.

Gen. PSALLIOTA Fr.

- (1) *Flaventes* J. Schaeffer
Psalliota augusta Fr.
Elvensis B. & Br.
arvensis (Schaeff.) Fr.
silvicola (Vitt.) Sacc.
villatica Brond. sensu Bres.
xanthoderma Genev.
 var. *lepiotoides* Maire
 var. *obscurata* Maire
 var. *grisea* Pearson
comtula Fr.
amethystina Quél.
russiophylla (Lasch) Fr.
dulcidula Schulz.
pallens (Lange) Rea
rubella (Gillet) Rea
- (2) *Rufescentes* J. Schaeffer
 (a) *Gill edge fertile*
Psalliota campestris (Linn.) Fr.
 (b) *Gill edge sterile*
Psalliota hortensis Cke.
 vaporaria (Vitt.) J. Schaeffer
 silvatica (Schaeff.) Fr.
 litoralis Wakef. & Pearson
 arenicola Wakef. & Pearson
- (3) *Sanguinolentes* J. Schaeffer
Psalliota sanguinaria Lange
 haemorrhoidaria Karst.
 exserta Rea non Viv.
- (4) *Immutabiles*
Psalliota flocculosa Rea
 impudica Rea

NOTES

Psalliota.—We have left out the numerous varieties of *P. campestris* and *P. arvensis* because it is not known with any certainty to which species they should be attached. On the other hand we have left in all the satellites of *P. comtula* though we have a suspicion that they could all be reduced to one species: *P. amethystina*.

Psalliota exserta Viv.—under this epithet Rea has described a bleeding mushroom which is not the *exserta* of Viviani, a non-bleeding species, though the original figures are misleading. Viviani states: '*la sua carne... si mantien bianca esposta all' aria*.' We have gathered Rea's species on chalk downs in Sussex but it requires further study before re-naming.

flavescens Gillet = *P. silvicola*.

perrara Schulz. = *P. augusta*.

peronata Mass. = *P. augusta*.

pratensis (Schaeff.) Fr.—identity uncertain—not unlikely to be one of the varieties of *P. xanthoderma*.

sagata Fr.—Cke. Ill. 1177 (968) may be a large *P. rubella*.

setigera Fr.—seems to have slipped in the British list by mistake.

subgibbosa Fr.—description insufficient. Cke. Ill. 551 (552) is *Pholiota aegerita*.

Pilosace Algeriensis Fr.—doubtful species; probably a *Psalliota* with ring rubbed off.

Clarkeinda O. Kuntz (*Chitonina* Fr.) = *C. rubriceps* (Cke. & Mass.) Rea. An alien species on soil in Aroid house.

Gen. COPRINUS Fr.

- I. *Pelliculosi* Fr.
 (a) *Annulati* Lange
Coprinus comatus (Fl. Dan.) Fr.
 ovatus (Schaeff.) Fr.
 sterquilinus Fr.
- (b) *Atramentarii* Fr.
Coprinus atramentarius (Bull.) Fr.
 fuscescens (Schaeff.) Fr.
- (c) *Tomentosi* Fr.
Coprinus picaceus (Bull.) Fr.
 similis B. & Br.
 lagopus Fr.
 radiatus (Bolt.) Fr.
 lagopides Karst.
 macrocephalus Berk.
 cinereus (Schaeff.) Fr.
 macrorhizus (Pers.) Rea
 echinosporus Buller

(d) *Phaeospori* Lange

Coprinus domesticus (Pers.) Fr.
urticaecola (B. & Br.) Buller
Friesii Quél.

II. *Farinosi* Lange(a) *Annulati*

Coprinus ephemeroides (Bull.) Fr.
Hendersonii Berk.

(b) *Exannulati*

Coprinus cordisporus Gibbs
Patouillardii Quél.
niveus (Pers.) Fr.
dilectus Fr. non Lange
roseotinctus Rea
narcoticus (Batsch) Fr.

Coprinus stercorarius (Bull.) Fr.
tigrinellus Boud.
stellaris Quél.
velox Godey
filiformis B. & Br.
curtus Kalch.
radians (Desm.) Fr.
micaceus (Bull.) Fr.

III. *Nudi* Lange

Coprinus tergiversans Fr. sensu Ricken
tardus Karst.
ephemerus (Bull.) Fr.
 f. *bisporus* (Lange) Joss.
congregatus (Bull.) Fr.
Boudieri Quél.
hemerobius Fr.
plicatilis (Curt.) Fr.

NOTES

- Coprinus alternatus* (Schum.) Fr.—not clearly defined.
apthosus Fr.—no British record. Cke. III. 653 (666) is a *Hypholoma*.
aquatilis Peck—insufficiently described.
aratus B. & Br.=large *C. micaceus*.
Bresadolae Schulz.—doubtful record.
bulbillosus Pat.=*C. ephemeroides*.
cothurnatus Godey—awaits fuller description.
cordisporus Gibbs—left in but may prove to be the same as *C. Patouillardii*.
deliquescent (Bull.) Fr.—not known to what this refers.
digitalis Fr.—needs confirmation.
eburneus Quél.—doubtful if a *Coprinus*. The violet almond-shaped spore suggests a white form of *Psilocybe coprophila*.
erythrocephalus (Lév.) Fr.=*C. dilectus* sensu Lange non Fr. British record is doubtful.
extinctorius (Bull.) Fr.=*C. micaceus*.
filiformis B. & Br.—left in on the strength of the spore measurements by Massee $5 \times 4\mu$, but a doubtful species.
finetarius (Linn.) Fr.=*C. cinereus*. The latter name was used in *Syst. Myc.* and the former cited as synonym.
floculosus DC.—problematical species; perhaps not a *Coprinus*.
frustulosum Sacc.—hardly different from *C. roseo-tinctus* which is retained, though it may be identified with *C. dilectus*.
Gibbsii Mass. & Crossl.=a form of *C. plicatilis*.
hemerobius Fr.—left in for further observation, but there is some doubt about its identity. It seems to be a large *C. plicatilis* with an elliptical spore, but this may only be the side view of the *plicatilis* spore.
nycthemerus Fr.—doubtful to what this refers.
oblectus (Bolt.) Fr.=*C. sterquilinus* sec. Buller.
papillatus (Batsch) Fr.—requires further elucidation; may only be *C. plicatilis*.
platypus Berk.—an alien.
plicatiloides Buller=*C. curtis*.
Schroeteri Karst.—not known; no British record found.
sociatus Fr.=*Psathyrella crenata*.
Speggazinii Karst.—an exotic.
Spraguei B. & Curt.—not a *Coprinus*.
squamosus Morg.—doubtful if distinct from *C. fuscescens*.

Coprinus truncorum (Schaeff.) Fr. = *C. micaceus*.

tuberosus Quél. = *C. stercorarius*.

tomentosus (Bull.) Fr.—another problematical species. To Ricken it seems little different from

C. micaceus but the Bulliard figure is not unlike *C. cinereus*.

umbrinus Cke. & Mass.—hardly differs from *C. sterquilinus*.

volvaceo-minimus Crossl.—seems identical with *C. Hendersonii*.

Gen. GOMPHIDIUS Fr.

Gomphidius rutilus (Schaeff.) Fr.

(= *viscidus*)

maculatus (Scop.) Fr.

Gomphidius gracilis B. & Br.

glutinosus (Schaeff.) Fr.

roseus Fr.

BOLETALES

Gen. STROBILOMYCES Berk.

Strobilomyces strobilaceus (Scop.) Berk.

Gen. PORPHYRELLUS Gilbert

Porphyrellus porphyrosporus (Fr.) Gilb.

Gen. GYROPORUS Quél.

Gyroporus cyanescens (Bull.) Quél.

Gyroporus castaneus (Bull.) Quél.

Gen. GYRODON Opat.

Gyrodon lividus (Bull.) Sacc.

Gen. BOLETINUS Kallbr.

Boletinus cavipes (Opat.) Klotzsch

Gen. PHYLLOPORUS Quél.

Phylloporus rhodoxanthus (Schweinitz) Bres.

Gen. BOLETUS Fr.

A. *Edules* Fr.

Boletus edulis (Bull.) Fr.

reticulatus (Schaeff.) Boud.

pinicola Vitt.

? *aereus* (Bull.) Fr.

Boletus albidus Roques

appendiculatus (Schaeff.) Fr.

regius Krombh.

? *fragrans* Vitt.

(*Ixocomus* Quél.)

(a) *Annulati*

B. *Rhodoporus* Quél.

(*Tylopilus* Karst.)

Boletus felleus (Bull.) Fr.

Boletus luteus (L.) Fr.

elegans (Schum.) Fr.

flavidus Fr.

viscidus (L.) Fr.

tridentinus Bres.

C. *Caerulescenti*

Boletus luridus (Schaeff.) Fr.

erythropus Fr. non Pers.

purpureus Fr.

Satanas Lenz

Queletii Schulz. var. *lateritius* Bres. &

Schulz.

calopus Fr.

(b) *Exannulati*

Boletus granulatus (L.) Fr.

bovinus (L.) Fr.

variegatus (Swartz) Fr.

sulphureus Fr.

piperatus (L.) Fr.

(*Xerocomus* Quél.)

Boletus chrysenteron (Bull.) Fr.
versicolor Rostk.
subtomentosus (Schaeff.) Fr.
parasiticus (Bull.) Fr.
pulverulentus Opat.
badius Fr.
craesinus Secr.
impolitus Fr.
rubinus W. G. Sm.

Trachypus Bataille

(*Krombholzia* Karst.)

Boletus scaber (Bull.) Krombh.
var. *coloripes* Singer
holopus Rostk.
versipellis Fr.
duriusculus Schulzer
crocipodius Letell.
Carpini (R. Schulza) Pearson

NOTES

- Boletus aestivalis* (Paul.) Fr.—pale form of *B. appendiculatus*.
alutarius Fr. = *B. fellea*.
aurantiporus Howse = *B. tridentinus*.
candicans Fr.—identity doubtful; probably *B. albidus*.
carnosus Rostk. = *B. badius*.
collinitus Fr.—probably *B. luteus* without ring.
cruentus Vent. = *B. impolitus*.
elegans Fr.—the valid name would appear to be *Boletus Grevillei* Klotzsch, *Linnaea*, vii (1832).
For the present the more familiar name may stand.
erythropus Pers. non Fr. = *B. Queletii*.
flavus (With.) Fr.—usually assumed to be identical with *B. elegans*.
laricinus Berk. = *B. viscidus*.
nigrescens Roze & Rich. = *B. crocipodius* Let.; of the many epithets applied to this species by modern authors, each has some point which appears to invalidate its priority. *B. crocipodius* is based on a good figure by Letellier (1838).
olivaceus (Schaeff.) Fr. = *B. calopus*.
pachypus Fr.—identity doubtful; either *B. calopus* or *B. albidus*.
paludosus Mass.—uncertain; may be a form of *B. badius*.
pruinatus Fr.—a doubtful species midway between *B. chrysenteron* and *B. versicolor*.
purpurascens Rostk.—looks like a form of *B. versicolor*.
pusio Howse ex B. & Br.—not adequately described.
Queletii Schulzer var. *rubicundus* Maire = var. *lateritius*. The type has not yet been recorded in Britain.
radicans Pers. non Fr. = *B. pulverulentus*.
radicans Fr. = *B. albidus*.
rhodoxanthus (Krombh.) Kallenb. = *B. purpureus*.
Rostkovii Fr.—named by Fries from Pl. 18 in Part III of Sturm's *Die Pilze Deutschlands*. Gilbert thinks it may be the same as *B. tumidus* Fr., but further observation required.
rubiginosus Fr.—suggests form of *B. reticulatus*.
rugosus Fr.—Fries in error adopted *Boletus rugosus* from Sowerby, who under this name illustrated a *Polyporus* which looks like *Daedalea biennis* (*Polyporus rufescens*). In *Hym. Eur.* Fries refers to Sowerby, t. 420, but this plate is named *Boletus lactifluus* and is obviously *B. granulatus*.
rutilus Fr.—uncertain what this refers to.
sanguineus (With.) Quél. = *B. craesinus* Secr.
sanguineus With. sensu Kallenbach. = *B. versicolor*.
scaber Bull.—it is an almost universal tradition that this refers to the common boletus of birch woods. Some French authors maintain that *scaber* should be adopted for a less common boletus described by Kallenbach as *pseudo-scaber*. This epithet had been previously used and gives place to *B. Carpini* originally described by Roman Schulz as a variety of *scaber*.
spadiceus—excluded from list to await clearer definition. It is probably only a form of *subtomentosus* with white flesh and very prominent anastomosing ribs on the stem.
sphaerocephalus Barla.—a luxuriant form of *B. sulphureus*.
tenuipes (Cke.) Mass. = *B. craesinus*.
variecolor B. & Br.—uncertain what this refers to.
vaccinus Fr.—from the description would appear to be a form of *Gyroporus castaneus*.

Gyrodon caespitosus Mass. = caespitose form of *Boletus pulverulentus*, with tubes not fully developed.
sistotrema Fr. = *Gyrodon lividus*.

rubellus McWeeney—probably *Boletus versicolor* with tubes not fully extended.

Most of the British records of *Gyrodon* probably refer to young specimens of *Boletus* when the tubes are short and the pores more or less labyrinthine. *G. lividus* is the only fully authenticated species.

Gyroporus lacteus (Lév.) Quél. = white form of *G. cyanescens*.

fulvidus (Fr.) Pat. = pallid form of *G. castaneus*.

Phaeoporus porphyrosporus (Fr.) Bat.—replaced by *Porphyrellus porphyrosporus*, the generic epithet *Phaeoporus* having been used by Schroeter for another genus of polypores.

Tylopus—replaced in *Boletus*, the only species *felleus* having too close an affinity with the *Edules* section to be put into a separate genus in spite of its pinkish spores.

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SOME LITTLE-KNOWN BRITISH SPECIES OF AGARICACEAE

I. LEUCOSPORAE AND RHODOSPORAE

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(With 5 Text-figures)

Many of the names applied by Berkeley, Cooke and Massee to British Agarics have fallen into disuse because the published diagnoses were so inadequate that the species could not be recognized again with confidence. Preparation of a revised list of British Agaricaceae, undertaken in collaboration with Mr A. A. Pearson, necessitated reconsideration of these forgotten species and made it desirable to examine such material of them as was available, with a view to supplementing the original descriptions by whatever microscopic characters were still discernible. It is hoped that some of these dubious names will be reduced to synonymy and others revived as valid designations of well-defined species. Some of them probably refer to rare fungi that have not been collected by any competent mycologist since they were first described. This paper deals only with white-spored and pink-spored species.

MATERIAL AND METHODS

The material examined consists of dried specimens, mostly of type collections, from the herbaria of Berkeley, Cooke and Massee now preserved in the Cryptogamic herbarium at Kew. Wherever practicable, a small fragment of pileus was detached, soaked in 10 % potash solution until softened and swollen to approximately fresh condition, transferred to dilute gum arabic solution and sectioned with the freezing microtome at right angles to the surface. The presence or absence of a specialized surface layer on the pileus was thus determined. Marginal portions of the gills were mounted in 10 % potash solution and examined for cystidia and spores and, in white-spored species with abundant spores, a separate mount was made in Melzer's reagent. A distinct dark blue coloration of the spore wall in this medium was observed only with *Armillaria jasonis* Cke. & Massee, *Mycena berkeleyi* Massee, and *Pleurotus laurocerasi* B. & Br.; spores of other species were unaffected or stained yellowish brown. Care is necessary in interpreting observations made on such material, most of which has been dried for from fifty to one hundred years and is often in a fragmentary or poorly preserved condition. The spores observed have not been shed naturally and many of them must have been immature when dried, hence they may often not have attained their characteristic size and shape. Moreover, the gills are frequently found to bear as many as three totally different types

of basidiospore, presumably because several collections had been carried in the same basket or vasculum and had shed spores on to one another. Many specimens also yield spores of various moulds, some probably parasitic, and here normal basidiospores can hardly be expected to be present. Hence one can only feel confident of identifying the right spore if one type clearly predominates over all others; only rarely can mature spores be found still attached to basidia. Cystidia, even of the thin-walled vesicular type, can usually be recovered in potash but in a few specimens the entire hymenium seems to have completely disorganized. Basidia are usually clearly discernible but the number of sterigmata is often doubtful.

No specimens can be found at Kew of the following doubtful species: *Lepiota emplastrum* Cke. & Massee, *Tricholoma duracinum* Cke., *Clitocybe zygophila* Cke. & Massee, *C. pergamenus* Cke., *C. occulta* Cke., *Collybia thelephora* Cke. & Massee, *Mycena consimilis* Cke., *Omphalia directa* B. & Br., *Hygrophorus aromaticus* Berk., *Entoloma liquescens* Cke., *E. fertile* Berk., *Nolanea fulvo-strigosa* B. & Br., *Nolanea rubida* Berk.

(1) *Lepiota polysticta* Berk. 1836, p. 9.

The type locality of *L. polysticta* was Cotterstock, Northamptonshire, 26 July 1828, and this collection cannot now be identified. Specimens exist in Berkeley's herbarium labelled 'King's Cliffe', and 'Coed Coch, Mrs Wynne Sep. 1865', and there is also an unlocalized collection now represented by two vertical sections of sporophores and two pressed specimens each consisting of a stipe and the skin of half a pileus about 3.5 cm. across. This sheet bears a pencil sketch of a spore with the dimension 00025. It is labelled in Berkeley's hand-writing '*Ag. polystictus* Berk.' and, if not type material, is at least a collection evidently studied in detail by the author of the species. This material was therefore chosen for re-examination. Kew also has two collections from the Hooker herbarium, labelled 'King's Cliffe ex herb. Berk.'; though authentic, these cannot be type material.

The skin near the centre of the pileus consists of hymeniform cells measuring about $10 \times 5 \mu$ resting on a tissue formed of narrow interwoven hyphae. Over the remainder of the surface the cuticle is broken up into rather conspicuous dark brown appressed squamules about 1.5 mm. across. The basidia are four-spored and the spores hyaline, non-amyloid, elliptical, $6-8 \times 3-4 \mu$, without a germ pore. The gill edge bears vesicular colourless cystidia approximately $25 \times 10-14 \mu$. The scales on the stipe, mentioned in the diagnosis, are no longer apparent.

This is quite a distinct fungus from that figured by Cooke as pl. 41 (30) which has no scales on the cap. Berkeley's species appears to fall in Kühner's section *Ovisporae* of *Lepiota* (Kühner, 1936) and may well be identical with *L. clypeolarioides* Rea.

(2) *Armillaria jasonis* Cke. & Massee in Cooke, 1888.

The type collection consists of a single cluster of five mature sporophores with a number of young ones growing out of a small mass of woody debris. The sheet is endorsed in pencil 'Carlisle Dr Carlisle *Lepiota* figd.' and

across this has been added in ink '*Ag. (Armillaria) Jasonis* C. & M. type'. The material is in good condition and sections of the pileus show it to be covered by a zone of rich brown globose or pyriform cells $15-25\mu$ across and up to five cells deep. Below this and of the same colour is a region of similar but collapsed cells sharply differentiated from the underlying flesh which consists of rather stout colourless loosely interwoven hyphae about 4μ thick. Spores are abundant, hyaline, ovoid or slightly asymmetrical with distinctly amyloid walls $6-8 \times 3-4\mu$. There are no cystidia.

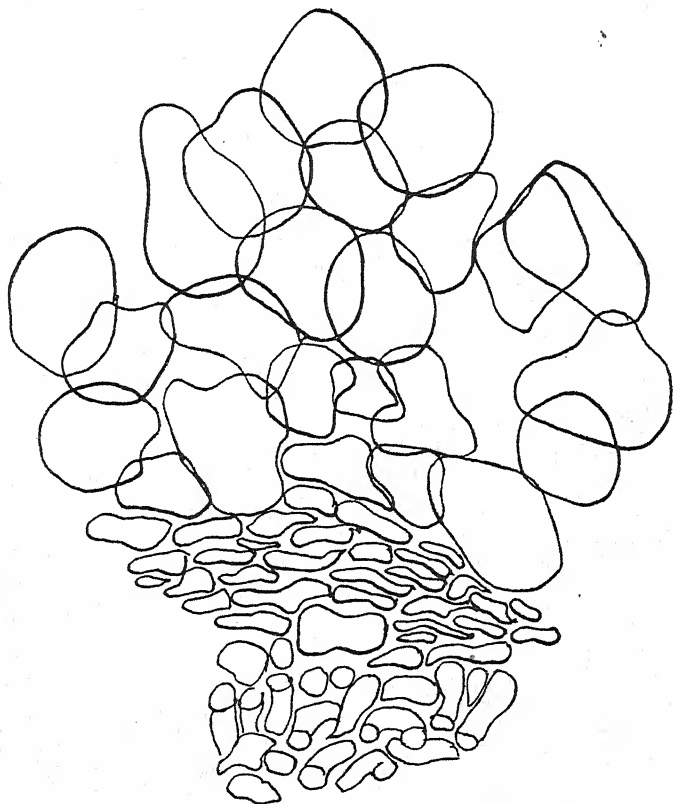


Fig. 1. *Armillaria jasonis*. Section through surface layers of pileus, $\times 750$.

Armillaria jasonis is evidently *Lepiota amianthina* (Scop.) Fr., as already suggested by Boudier (1907), and by Quélet, Maire and Rea in Pearson (1935). It may be compared with var. *longispora* Kühner (1936), also found on rotting stumps, if that form is worth a varietal name.

(3) *Tricholoma circumtectum* Cke. & Massee, in Cooke, 1883-91, p. 382.

The type collection contains three dried and rather flattened sporophores labelled in Cooke's handwriting '*Ag. (Tricholoma) Kew Aug/88*'. Attached to the same sheet is a copy of Cooke's pl. 1125 (1182) which bears the date Sept. 1888 and therefore presumably does not represent these specimens.

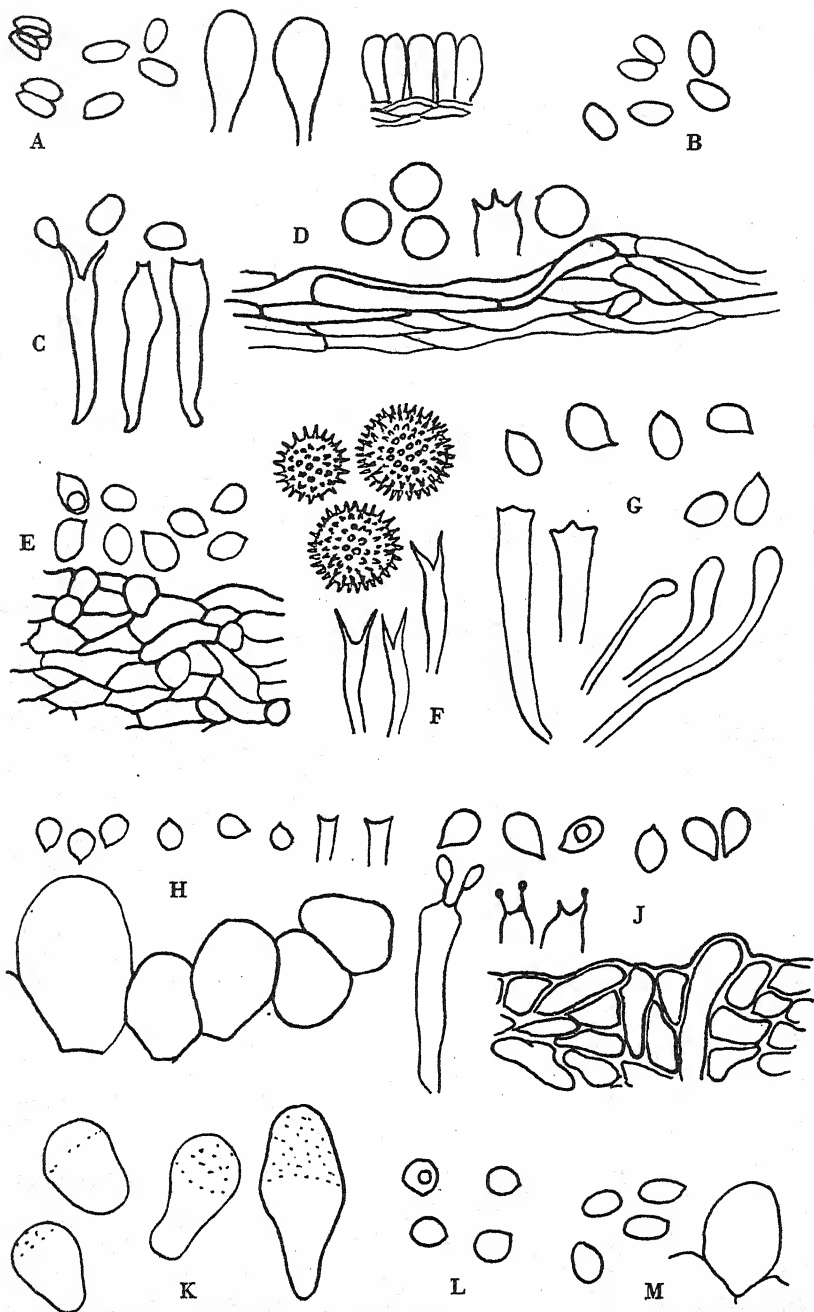


Fig. 2. A, Spores, cystidia from gill edge, and section of cuticle of pileus in *Lepiota polysticta*. B, Spores of *Armillaria jasonis*. C, Basidia and spores of *Tricholoma circumtectum*. D, Spores, basidium and section of surface of pileus in *Tricholoma tenuiceps*. E, Spores and section of surface layers of pileus in *Clitocybe obscurata*. F, Spores and basidia of *Laccaria nana*. G, Spores, basidia and surface hyphae in *Hygrophorus cerasinus*. H, Spores, basidia and section of cuticle in *Hygrophorus micaceus*. J, Spores, basidia and section of cuticle in *Hygrophorus ventricosus*. K, Cystidia of *Collybia psathyroides*. L, Spores of *Collybia eustegia*. M, Spores and cystidium (?) of *Collybia stevensonii*. All $\times 750$.

The material is in rather poor condition and had evidently begun to decay before being dried as the tissues are much contaminated with bacteria. It yields abundant non-amyloid hyaline broadly elliptical spores $5-7 \times 2.5-4 \mu$ borne on rather elongated basidia approximately $25-30 \times 5-7 \mu$. Very few basidia still retain sterigmata but some at least appear to have been two-spored. There are no cystidia. The surface of the pileus consists of interwoven hyphae with no distinct cellular cuticle. In Pearson (1935), Maire suggested the fungus was *T. atrosquamosum*. Quélet thought it was *T. argyraceum* (Bull.) Fr. The former should have sterile dark cells on the gill edge, not seen in Cooke's material; the latter identification may be correct but it is unwise to conclude more than that *T. circumtectum* represents a member of the *T. myomyces* group, probably the form called *T. sculpturatum* (Fr.) Quél. by Bresadola (1881-92) and by Konrad and Maublanc (1924-37).

(4) *Tricholoma tenuiceps* Cke. & Massee in Cooke, 1883-91, p. 398 (? 1891).

Of this species there are preserved portions of six or seven sporophores, three still united at the base, labelled 'Ag. (*Tricho.*) *tenuiceps* C. & M. Kew July 1888'. The surface of the pileus consists of prostrate interwoven hyphae with brown contents, apparently coated with colourless gelatinous material which swells in potash. There is no sharp distinction between cuticle and flesh. The basidia are four-spored; the spores globose to subglobose, non-amyloid, $7-8 \times 6-7 \mu$. There are no cystidia.

Evidently this is *T. aggregatum* (Schaeff.) Quél. as stated by Rea in Pearson (1935). Maire suggested it might be a form of *Collybia platyphylla* (Pers.) Fr., influenced no doubt by the cord-like mycelial strands indicated on Cooke's pl. 1121 (1166), but the globose spores are not those of that species.

(5) *Clitocybe obscurata* Cke, 1909.

The specimen of *C. obscurata* in Kew Herbarium consists of a single pileus, now 4 cm. across, with strongly decurrent gills. The lower part of the stipe is wanting and the pileus is firmly glued to the sheet by the whole upper surface. Hence the nature of the cuticle could only be investigated near the margin, where it is composed of rather stout, closely interwoven hyphae, $3-4 \mu$ thick, forming a zone some 30μ deep, overlying the rather spongy loosely woven flesh. The spores are hyaline, broadly elliptical non-amyloid, $5-6 (-8) \times 3.5-4 (-5) \mu$. This specimen is labelled 'Miss Graham coll. *Clitocybe obscurata* Cke. on the ground Edmond Castle, Carlisle, Oct. 1908'. 'Recd. 14. xi. 08.' According to the diagnosis the type collection was made in September 1908 by the same lady in the same locality; possibly there has been some confusion of dates. As regards microscopic characters there seems nothing to separate this collection from *C. clavipes* (Pers.) Fr. to which Cooke thought it allied. His figure (Cooke, 1909, t. 5c) could represent an old specimen of that species in which the swollen base of the stipe was not developed. From *C. subinvolutus* W. G. Sm. it is distinguished by the absence on figure or specimen of any indication of an involute margin.

(6) *Laccaria nana* Masee, 1913.

In view of Lange's discovery (Lange, 1935-40) of a fungus closely resembling *L. nana*, but differing from Masee's diagnosis mainly in spore size and number of sterigmata, it seemed desirable to re-examine the type material of that species. The collection, labelled '*Laccaria nana* sp. nov. K.G. 3/12' consists of four dried sporophores in which the structures of trama and pileus are no longer distinguishable. The basidia are, however, well preserved, long and slender, about $10 \times 3 \mu$, each with two well-developed sterigmata $6-7 \mu$ long. The spores are spherical, $9-12 \mu$ across, bearing spines 2μ long, about thirty of which can be counted in the circumference of a spore 12μ in diameter. Lange's fungus is thus clearly distinct from Masee's.

(7) *Hygrophorus cerasinus* Berk. 1836, p. 12.

Berkeley's herbarium contains portions of at least two pilei, of diameters 2.7 and 4.5 cm. respectively, with stipes as far as visible 4.8×0.4 and 3.7×0.9 cm., glued by their lower surfaces to the same sheet as four vertical sections of sporophores with pilei 2.6, 4.4, 4.3 and 4.1 cm. across. All are riddled by mites and the gills of the three larger sections originally some 2-3 mm. broad, now consist mainly of frass. Those of the smallest section, though very narrow, are fairly well preserved. The sheet is labelled '*A. cerasinus* Berk. Winkbourn, Notts. 1833' and is evidently type material.

The surface of the pileus consists of slender brown hyphae embedded in mucilage. The basidia were apparently four-spored but sterigmata are not well preserved. The spores are hyaline, broadly elliptical and strongly apiculate, $8-9 \times 4-6 \mu$. There seems no adequate grounds for attempting to separate this species from *Hygrophorus* (*Limacium*) *agathosmus* Fr. The name *Agaricus agathosmus* was coined by Fries (Fries, 1815, p. 17) for a fungus distinguished from *Ag. pustulatus* Persoon (Persoon, 1801) by its pleasant smell, colour and size. In the *Systema*, however (Fries, 1821, i, 34), he changed his mind and cited *A. agathosmus* as a synonym of *A. pustulatus* Pers., making no reference to the odour. Later (Fries, 1836, p. 325) he changed his mind again and re-established *Hygrophorus agathosmus* as a distinct species. Secretan (1833) gave detailed descriptions of a fungus which he named, no doubt correctly, *Agaricus agathosmus* Fr. Hence *Hygrophorus agathosmus* (Fr. ex Secretan) Fr. is apparently the valid name for the species.

(8) *Hygrophorus micaceus* B. & Br. Notices No. 1779, March 1879.

The type sheet bears five poorly preserved sporophores and traces of others and is labelled '*Hygrophorus micaceus* B. & Br. Coed Coch. Oct. 1878'. The largest remaining pileus is 4 mm. across with a stipe 18×0.5 mm. and has a cuticle of brown, globose or broadly pear-shaped cells, approximately $15-20 \mu$ across, which perhaps gave the 'micaceous' appearance to the surface. The basidia are slender, possibly only two-spored, with spores subglobose, $4-5 \times 3.5-4 \mu$. There are no cystidia. This seems to be a distinct

species closely related to *Omphalia atropuncta* (Pers.) Quél., which Lange (1935-40) has transferred to *Camarophyllus*.

(9) *Hygrophorus ventricosus* B. & Br. Notices No. 1777, March 1879.

Berkeley's herbarium contains two well-preserved sporophores under this name accompanied by two vertical sections, from one of which the pileus has been broken away and lost. All are firmly glued to the same sheet labelled '*Hygrophorus ventricosus* B. & Br. Coed Coch 1878'. The existing pilei measure 2.6, 2.3 and 2.4 cm. in diameter and the stipes below the deeply decurrent narrow gills measure 5.0×1.0 , 4.4×1.2 and 5.0×1.0 cm. respectively. There is no distinct cuticle, but the surface of the pileus consists of closely interwoven hyphae about $4-5\mu$ in diameter with no mucilaginous outer covering. The basidia seem to have been two-spored and the spores hyaline, non-amyloid, $7-10 \times 4-5\mu$, with a well-developed basal apiculus. The upper figures in Cooke's pl. 897 (901) no doubt represent the above collection and were thought by Maire in Pearson (1935) to be *H. virgineus*. This seems likely enough for, according to Lange, two-spored forms of that species do exist.

(10) *Collybia eustygia* Cke. Dec. 1890.

The type packet contains one and a half dried sporophores, the larger now of maximum diameter 3.3 cm. with a stipe 8 mm. thick, and is labelled '*Ag. (Collybia) eustygus* C. & M. Whitfield 1890'. Pilei and stipes alike are dark chestnut brown shading to black, the gills dark grey to almost black. The surface of the pileus consists of interwoven hyphae with no distinct cuticle. The basidia are poorly preserved, mostly about $30 \times 6\mu$ with sterigmata no longer visible and all have deep brown contents, giving the blackish hue to the gills. There are no cystidia. The spores are hyaline, non-amyloid, subglobose $5-6 \times 4-5\mu$.

From *C. rancida* Fr. this species is clearly distinguished by its much stouter stature and subglobose spores. *C. eustygia* is probably a slender form of the fungus described by Lange (1935-40) under the name *Tricholoma crassifolium* (Berk.) Ricken and the lower central figure and upper left section in Cooke's pl. 1146 (1185) accords reasonably well with Lange's pl. 25c. The fungus is, however, clearly not *Ag. crassifolius* Berk. as Lange admits. *Collybia eustygia* apparently differs from *Tricholoma immundum* Berk. sensu Cooke, pl. 81 (61) and Bresadola (1881-92, pl. 156) only in its rooting base. Unfortunately, though there is abundant material of *T. immundum* in Berkeley's herbarium labelled 'Moelfre uchaf, Denbighshire Oct. 1859' it all appears to have been collected in bad condition with almost sterile hymenium bearing mainly the subglobose, spiny, non-apiculate spores of a parasite. Occasional subglobose smooth apiculate spores do occur and one apparently still attached to a basidium measures $7 \times 5.5\mu$. The hymenium of *T. immundum* has the same brown cell contents as *Collybia eustygia*. Bresadola, and both Maire and Rea in Pearson (1935) agree in regarding *Tricholoma immundum* as the same as *Ag. fumosus* Persoon. There is, however, some doubt which of the blackening species of *Tricholoma* or *Collybia* Persoon had, and also whether Fries used the name

Agaricus fumosus in the same sense as Persoon. It is proposed, therefore, to adhere in the meantime to the name *Tricholoma immundum* Berk.

(11) *Agaricus crassifolius* Berk. 1860.

The type collection of this species was made at Winkbourn, Notts and has not been preserved. Berkeley's herbarium contains a dried, pressed specimen consisting of the cuticle of a pileus now 7 cm. across, with stipe 5×1.4 cm. tapering to the base, and a vertical section showing sinuate gills 7 mm. broad. These are labelled '*A. crassifolius* B. Cecil H. Spencer Percival' and are evidently the collection published in Notices 1503*, 1876. There is also a water-colour drawing of three sporophores, the largest pileus 6.2 cm. across, labelled '*A. pachyphyllus* nob.' which is the source of Cooke's pl. 93 (92) and presumably depicts the Winkbourn material. Both Spencer Percival's fungus and the unlocalized drawing have a slightly scurfy fibrillose pileus like that of *Tricholoma* of the *Myomyces* group. This, taken in conjunction with the occurrence of the type in fir woods, is sufficient to disprove the suggestion by Quélet and Maire in Pearson (1935) that *Agaricus crassifolius* is *Tricholoma georgii*. That it is not the fungus for which the epithet *crassifolius* has been used by Bresadola and Lange is clear from Berkeley's diagnosis, and from the specimen in his herbarium if that be accepted as authentic. Unfortunately, it has been much eaten by insects and its spores cannot be identified with certainty, though there are a few hyaline elliptical spores $6-7 \times 4\mu$ present on the gills. The gills are now brown, not grey or black as in *T. immundum*, and the surface of the pileus consists of matted hyphae about 3μ in diameter.

(12) *Collybia psathyroides* Cke. June 1883.

The type collection, Epping Oct. 1880, contains the halves of a single sporophore with pileus now 1.4 cm. across and 1.0 cm. high, very thin flesh and broadly adnate gills 7 mm. deep at their attachment to the stipe. There remains about 1.5 cm. of a hollow stipe, some 2 mm. thick, but the continuation of the stipe has been indicated on the sheet by a pencil outline to a total distance of 6.3 cm. from the pileus. The cuticle of the pileus is much disorganized but appears to have consisted of fine interwoven hyphae embedded in mucilage. The gills have an uneven surface and look abnormal. No spores can be found corresponding to those mentioned in the diagnosis 'white, elliptical $15 \times 7\mu$,' there remain only the broadly elliptical or sudglobose hyaline spores of a parasite measuring $5-6 \times 4-5\mu$ and brown spores $12-16 \times 8-10\mu$ obviously alien, scattered rather freely over the gills. Cystidia are very abundant on the gill face and edge; most are pyriform and probably once bore a crown of spines as in many species of *Mycena*, for their apices are now obscurely punctate. The fungus was probably a diseased condition of some *Mycena* and the name should be discarded.

(13) *Collybia stevensonii* B. & Br. Notices No. 1497, Jan. 1875.

Berkeley's herbarium contains two sheets of this species each bearing two specimens, a vertical section and a half pileus, presumably of the same individual. All are much damaged by insects so that the gill attachment

is no longer discernible. The large pileus is now 1.55 cm. across, the longest stipe 4.5 cm. \times 1 mm. and the gills 3 mm. broad, but this may be an underestimate owing to the edge being broken away. The collection was labelled by Berkeley 'Ag. (*Collybia*) *Andersoni* Glamis' and bears also a separate label 'described under the name of *Agaricus stevensonii* B. & Br. Ann. Nat. Hist. No. 1439 M.C.C.' Neither Berkeley and Broome, Cooke, pl. 199 B, Cooke (1883-91) nor Stevenson (1886) state the size of the spores; Rea's (1922) measurement, $10-11 \times 7-8 \mu$, is copied from Masee (1893).

The surface of the pileus was described as viscid and consists of slender hyphae, $2-3 \mu$ thick, embedded in mucilage; that of the stipe is smooth and free from cystidia-like hairs. Numerous vesicles, possibly to be interpreted as thin-walled cystidia are scattered over the gill face. They are elliptical in outline and some have brown oily contents. Spores are very scanty, the few found were hyaline, non-amyloid, and measured $6-8 \times 3-4 \mu$. The stature and long rooting base of this fungus suggest *Marasmius esculentus* (Wulf.) Karst. or *M. conigenus* (Pers.) Karst. but the viscid pileus is not that of those species. It seems likely that the type collection was abnormal or even diseased.

(14) *Mycena berkeleyi* Masee, 1893, p. 104.

The type consists of three specimens labelled by Berkeley 'Ag. (*Mycena*) *excisus* Hothorpe Nov. 15, 1881' and a water-colour sketch by R. E. Berkeley which was faithfully reproduced as Cooke, pl. 224 (148). Spores are very abundant, broadly elliptical; $7-10 \times 5-6 \mu$ with distinctly amyloid walls. The basidia were probably four-spored and cystidia are no longer apparent but Maire's suggestion in Pearson (1935) that *M. berkeleyi* was a form of *M. galericulata* (Scop.) Fr. appears highly probable.

(15) *Mycena paupercula* Berk. 1836, p. 57.

Berkeley's herbarium contains two sheets under this name viz:

(a) *Agaricus pauperculus* Clifton, Notts, eight specimens originally collected in excellent condition, sporing freely but now much riddled by insects. One pileus has been lost, the remainder now measure, 2, 2.5, 4.5, 3, 4, 4 and 3 mm. in diameter respectively, with stipes 8, 4 (+7 mm. of root), 5 (+2), 5 (+2), 8 (+3), 7 (+3), 7 (+4), 11 (+20) mm. long and 0.5-0.75 mm. thick. These are presumably the types, collected 20 Sept. 1832 and are accompanied by a water-colour sketch of seven pilei growing on decayed wood or detached to show the long rooting base. The sketch is labelled 'A. *pauperculus* nob.' and is the original of Cooke's pl. 231 (236).

(b) No. 3158 *Ag. pauperculus* Berk. Texas C. Wright, seven specimens macroscopically similar to (a) and apparently growing on dead wood but without the long rooting base. Both in cuticle and spores they closely resemble the types but the pilei are much more distinctly striate.

The following observations relate to collection (a). The surface of the pilei consist of thin-walled, rather swollen, radiating hyphae containing dark brown granules. The basidia are four-spored clavate, about $20 \times 5-6 \mu$ with non-amyloid spores $7-8 \times 3.5-5 \mu$. No cystidia have been detected. The surface of the stipe is smooth.

If this is a *Mycena* it would appear to fall in Kühner's (1938) subgenus *Para-Mycena*, section *Omphalariae*, *nudae*. It differs, however, from any species there described in its narrow ascending gills, habitat and rooting base. Probably it is a good species which should be sought for and compared with *Collybia muscigena* (Schum.) Fr.

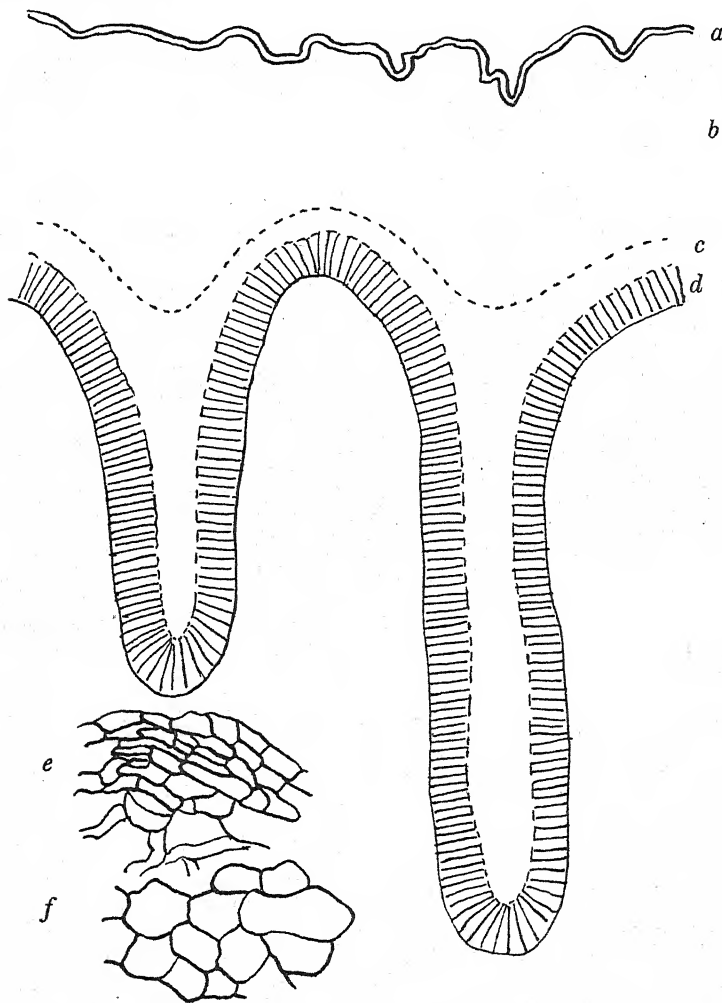


Fig. 3. *Omphalia abhorrens*. Section of pileus $\times 175$. a, Cuticle. b, Spongy tissue. c, Compact trama and subhymenium. d, Hymenium. e, Cuticle in section $\times 750$. f, Cuticle in surface view $\times 750$.

(16) *Omphalia abhorrens* B. & Br. Notices 1751, March 1879.

The type collection contains twelve sporophores, with stipes up to 15×1.5 mm. and pilei up to 10 mm. across, labelled 'Ag. (*Omphalia*) *abhorrens* B. & Br. Coed Coch, odor stercorarius'. Microtome sections of

the pileus show it to have a distinct yellowish brown cellular cuticle some 15μ thick and 5-6 cells deep, covering a rather loosely woven, colourless, spongy flesh. The spores are subglobose, non-amyloid, $4-6 \times 4-5\mu$. There are no cystidia. This seems to be a well-defined species which should be easily recognizable when encountered again, but is it not the same as *Hygrophorus foetens* Phillips? (Dec. 1878).

(17) *Omphalia alutacea* Cke. & Massee in Massee, Dec. 1892.

This species is represented in Cooke's herbarium by four well-preserved sporophores of the type collection, labelled '*Agaricus* (*Omphalia*) *alutaceus* C. & M. amongst grass Dinmore 1892'. The pilei are umbilicate with involute margins and now measure 10, 8, 8 and 6 mm. respectively with stipes 36, 34, 33 and $24 \times 0.5-1.5$ mm. The gills are about 1 mm. broad and decurrent. There is no cellular cuticle, the surface of the pileus consists merely of more or less radiating interwoven hyphae. The basidia are four-spored; the spores hyaline, non-amyloid, broadly elliptical, with a basal apiculus $7-9 \times 4.5-5\mu$. There are no cystidia. The species, if distinct, is apparently close to *Clitocybe infundibuliformis* (Schaeff.) Fr.

(18) *Omphalia telmatiaea* Berk. & Cke. in Cooke, 1883-91, p. 93 and Cooke, March 1884, p. 66.

The name was published without diagnosis but citing Cooke, pl. 224 in *Grevillea*, 1884. This species has been much confused. The diagnosis in Cooke's Handbook cites 'Cooke Illus. t. 224 *Ag.* (*Omphalia*) *affricatus* B. & Br. in Handbook No. 216 not of Fries'. On referring to this we find cited Berkeley and Broome, Notices No. 994 and specimen from Aboyne, Aberdeenshire. Berkeley and Broome under No. 994 state 'Aboyne, Aberdeenshire, at the top of the Queen Hill, Aug. 9, 1862. Pileus... brown, then mouse coloured....'

Berkeley's herbarium contains the following relevant material:

(a) One sporophore 1.2 cm. across labelled '*Ag.* (*Omphalia*) *affricatus*, Aboyne 1862', to which has been added, 'Berk. non Fries'. This has subglobose, non-amyloid spores $7-8 \times 5-6\mu$ and no cystidia.

(b) and (c) Two sporophores attached to *Sphagnum*, labelled '*Ag. affricatus* Fr. Clova, July, 1876, Dr Thomson'.

(d) A water-colour drawing showing two views of a pileus 2.1 cm. across with stipe 15-20 mm. labelled '*Ag. affricatus* pileo infundibuliforme umbilicato hygrophano e fusco murino subtilita affricato. Lamellis distinctis distantibus abrupti deliniatibus decurrentibus. Stipite compressis (?) basi tomentosis. Aboyne Aug. 9, 1862, *Omphalia*.' Stipe and pileus alike are represented as slate-blue, somewhat as in *Leptonia chalybaea*. This is clearly a drawing of (a) but bears no resemblance to Cooke's pl. 256 (240) which figures specimens collected by Massee at Scarborough and not preserved at Kew. Berkeley's drawing has been endorsed, apparently by Cooke '=*telmatiaeus* Berk. & Cke.'

Berkeley and Broome, No. 994, and Cooke, t. 256 (240), are surely not the same species and neither bears any resemblance to Fries' (1867 t. 75) figure of *Omphalia affricatus*. The diagnosis of *O. telmatiaea* states 'Pileus 2 in.

broad, stem $1\frac{1}{2}$ in. long'. This agrees with Cooke's plate but not with Berkeley and Broome, No. 994, which was described as $\frac{3}{4}$ in. across. Hence the Scarborough collection must be accepted as the type of this species and no opinion on its identity can be based on the material at Kew.

(19) *Omphalia infumata* B. & Br. Notices No. 1851, Feb. 1881.

Berkeley's herbarium contains three sporophores of this species, the largest pileus 8 mm. across, and one stipe from which the pileus has been lost, all attached to moss. The stipes measure 26, 23 and about 20×1 mm., swollen at the base to about 3 mm. The sheet is labelled '*A. (Omphalia) infumata* B. & Br. Garthwin 1880'. There is no specialized cuticle, the surface of the pileus is formed of prostrate hyphae with slightly swollen tips; the stipe is smooth. There are no cystidia. The basidia are cylindrical, about $35 \times 6\mu$, and probably four-spored though sterigmata are no longer clearly visible. The spores are broadly elliptical to elliptic-oblong or slightly inequilateral with a basal apiculus, non-amyloid, $8-10 \times 4-5\mu$.

(20) *Pleurotus hobsoni* Berk. 1860, pp. 138-9.

The type sheet bears eight sporophores attached to moss and labelled '*Agaricus (Pleurotus) Hobsoni* B. Apethorpe, Sept. 1859'. The largest measures 7 mm. across by 4 mm. from back to front; all are sessile with well-developed gills now about 0.5 mm. wide. The surface of the pileus is formed of rather loosely woven hyphae. The basidia were probably four-spored with hyaline, non-amyloid, elliptical spores $6-10 \times 5-6\mu$ and there are no cystidia. Unfortunately the gills yield a rather mixed collection of spores, but many of those present are certainly longitudinally ridged and this may well be *Clitopilus pleurotelloides* (Kühner) Jossierand. Berkeley apparently did not take a spore print so one cannot tell whether the spores were pink in the mass or not. In addition to the microscopic characters there is fair agreement in the macroscopic appearance of *Pleurotus hobsoni* and *Clitopilus pleurotelloides* as shown in the following comparative table:

Pleurotus hobsoni after Berkeley's
diagnosis

1. Pileus membranaceous
2. Reniform or dimidiate
3. Stemless
4. Pale grey
5. Minutely downy
6. Gills rather distant
7. Gills pallid
8. On larch stumps
9. Pileus 1-4 lines across
10. Margin involute
11. September

Clitopilus pleurotelloides according to Jossierand (1941)

1. Pileus non-hygrophanous, dry
2. \pm irregular, reniform, auricular
3. Soon becoming laterally attached or even resupinate
4. Snow white
5. Finely pubescent, when young, surface felted when old
6. Gills fairly crowded
7. Gills ivory white, then cream and pale ochraceous cream, a little tinged rosy
8. On rotting or mossy bark
9. Pileus 4-15 mm.
10. Edge subobtuse when young
11. June-October.

In view of the poor condition of Berkeley's collection it seems undesirable, however, to make a new combination for it in *Clitopilus*. It would seem wise to discard the name *Pleurotus hobsoni* Berk.

- (21) *Pleurotus laurocerasi* B. & Br. Notices No. 1854, Feb. 1881.

The type consists of a single flattened, unstalked fructification about 2 cm. across and 1-4 cm. from base to margin. Berkeley's label reads '*Ag. (Pleurotus) laurocerasi* B. on Laurel Coed Coch' and to this Dr A. Pilat has added '*Pleurotus tremens* Qué! probabilititer identicus 29. xi. 1934'. *P. laurocerasi* has no cystidia and amyloid, broadly elliptical smooth spores $9-12$ (-13) \times $7-8\mu$. According to Quélet (1877) *P. tremens* had spherical aculeate spores measuring $6-7\mu$ and he so figured them. These recall those of *P. palmatus* (Bull.) Fr. as already pointed out by Lloyd (1901).

Pilat (1935) says of this specimen 'En tant qu'on peut juger de ce mauvais exemplaire, c'est un champignon, dont le chapeau et les lamelles ont une consistance gélatineuse. Basides $20-28 \times 5-6\mu$. Sans cystides. Hyphes de la trame des lamelles à parois minces, gélatineuses, hyaline, densément et parallèlement entrelacées, épaisses de $7-11\mu$. Hyphes du chapeau analogues. Spores largement et subsphériquement ovoïdes, avec un apicule minuscule à la base, hyalines, $8-8.5 \times 6-6.5\mu$, avec des granules gélatineux collés à la surface, ce qui, leur donne une apparence squamuleuse. Apparemment une bonne espèce, assurément fort rare.'

There is a large number of subspherical spores of the size quoted by Pilat but as there are also many broadly elliptical large ones I have taken the former to be immature. The squamulose or wrinkled surface is not easily seen even in Melzer's reagent and cannot be detected at all in many of the larger spores.

- (22) *Pleurotus ruthae* B. & Br. Notices No. 1754, March 1879.

Berkeley's herbarium contains two specimens under this name. The smaller is well preserved and labelled '*Ag. (Pleurotus) ruthae* B. & Br. Coed Coch Oct. 1878', but there is also a larger, very much decayed, unlocalized fructification and a water-colour sketch dated 'Coed Coch '79'. Dr Pilat has attached a note to each specimen determining it as *Pleurotus petaloides* (Bull.) Fr. The smaller sporophore has abundant, fusiform, thick-walled cystidia measuring about $80-100 \times 12-16\mu$ scattered over the gill and smooth, hyaline, non-amyloid spores $7-9$ (-10) \times $4-5.5\mu$. It is no doubt *P. petaloides*. Pilat (1935) accepts the smaller specimen as typical of that species and the large as approaching the var. *geogonius* (DC.) Pilat.

- (23) *Pluteus spilopus* B. & Br. 1871, p. 532.

Pluteus spilopus was described by Berkeley and Broome from a dried specimen and figure sent them from Ceylon. Subsequently (Notices No. 1856, 1881), they published it from Britain. Berkeley's herbarium contains a single sheet labelled '*Ag. (Pluteus) spilopus* B. & Br.' bearing a pressed half sporophore and four vertical sections. This is unlocalized but can be identified with the Ceylon material as it has the No. 1167 quoted in the diagnosis. As the British collection is not available for comparison no final opinion can be expressed regarding its identification with *P. spilopus*. As tropical fungi have seldom been found to be identical with temperate

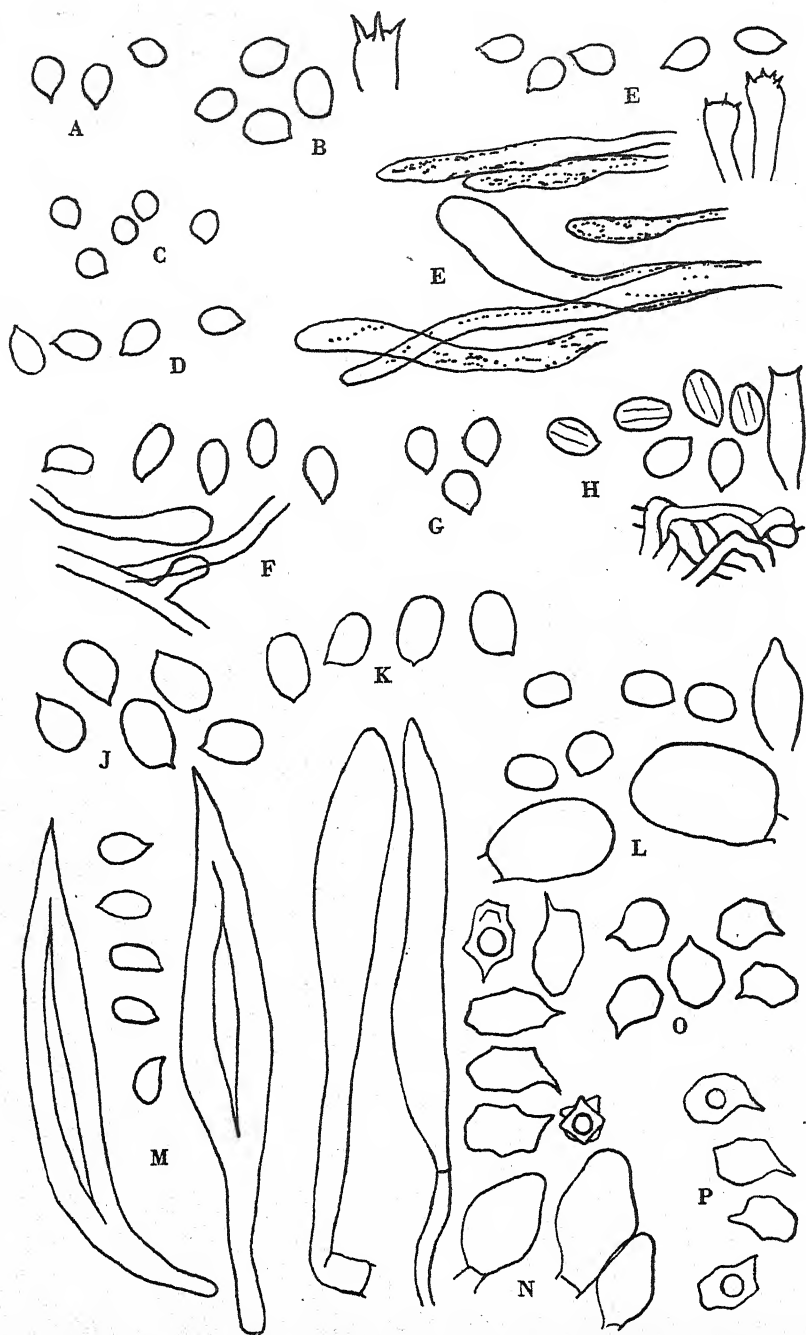


Fig. 4. A, Spores of *Tricholoma crassifolius*. B, Spores and basidium of *Mycena berkeleyi*. C, Spores of *Omphalia abhorrens*. D, Spores of *Omphalia alutacea*. E, Spores, basidia and surface hyphae from pileus of *Mycena paupercula*. F, Spores and surface hyphae in *Omphalia infumata*. G, Spores of *Omphalia telmatiaea* (Aboyne specimen). H, Spores, basidium and surface section of pileus in *Pleurotus hobsoni*. J, Spores of *Pleurotus laurocerasi*. K, Spores of *Entoloma bulbigenum* (Sibbertoft collection). L, Spores, cystidium and cuticular cells of pileus of *Entoloma thomsoni*. M, Spores and cystidia of *Pleurotus ruthae*. N, Spores, cuticular cells and hairs from pileus of *Entoloma wynniae*. O, Spores of *Clitopilus sarcinus*. P, Spores of *Clitopilus stilbocephalus*. All $\times 750$.

species, however, it seems highly improbable that they were the same and *P. spilopus* should be deleted from the British list until confirmed by a fresh collection.

(24) *Entoloma bulbigenum* B. & Br. Notices No. 1937, March 1882.

There has been deplorable confusion over this name. Berkeley and Broome in coining it gave no diagnosis but stated: '*A. (Entoloma) bulbigenum* B. & Br.; *A. Persoonianus* Phill. Gard. Chron. 1881, p. 874; *A. sericeus* Pers. Ic. et Descr. t. 6, f. 2. East Dereham, Rev. J. M. Du Port. Sibbertoft, Norths. Feb. 1882, Miss Ruth Berkeley.' Just the plant of Persoon, who indicates in his figure the sclerotoid bodies at the base, though he does not mention them in the text. The name of *A. persoonianus* requires to be changed as there is a species of similar name. 'Fr. Hym. Eur. p. 25. Spores 0.0004 to 0.0005 inch in diameter.' The reference to Fries (1874) is to *Ag. (Amanita) persoonii* Fr. and seems scarcely to necessitate a change of name. Evidently Berkeley believed himself to be renaming Phillip's fungus. His herbarium contains under this name only two dried sporophores and a vertical section from the Sibbertoft collection, accompanied by a water-colour drawing. The 'sclerotoid bodies' are merely enlarged bases of the stipes, which are shown to be distinctly floccose in the lower third. A fragment of a dead tree leaf is attached to the base of one stipe. This fungus has broadly elliptic-oblong, hyaline spores $11-12 \times 5-6.5 \mu$ and broadly adnate gills tinted pink in the drawing. There are no cystidia. Probably it was a *Marasmius* or a *Collybia* and is certainly not the same as the fungus figured by Phillips (1881) as having bottle-shaped encrusted cystidia and star-shaped spores suggestive of a form of *Inocybe fibrosa* (Sow.) Fr. Phillips identified his fungus with *Agaricus sericeus* Persoon and merely quoted Persoon's diagnosis with the additional and evidently erroneous statement that the plant was an *Entoloma*. He gave no spore measurements. Phillips and Plowright (1881) however, in a contemporaneous note, stated that 'the bulb in our plant is much more decided than in Persoon's figure having a distinctly abrupt margin, and the pileus is not so fleshy. The large angular spores are as wide as the basidia and the hymenium abounds with large cystidia. Spores, including the angles; 0.015 mm.' They still believed themselves to be merely renaming Persoon's *Ag. sericeus* which Fries had placed as a variety β of *Ag. sericellus* Fr. In view of the discrepancies noted by them, their meagre description and published figure may perhaps be taken as the diagnosis of a new species of which Du Port's Norfolk collection will then be the type.

It is noteworthy that in the same issue of *Grevillea*, Cooke (1881) published the name *Ag. (Entoloma) persoonii* Du Port, again citing both *Ag. sericeus* Persoon and the Norfolk fungus. His pl. 324 (315) is in the upper part a copy of Berkeley's water-colour of the Sibbertoft collection, in the lower half a copy of Persoon's figure of *A. sericeus* (Persoon, 1798, t. vi. fig. 2) as regards the section and the fructification to the left. That in the lower right corner is probably merely a product of Cooke's imagination supplied to fill the space and balance the plate. Whether Cooke ever saw Du Port's fungus is doubtful but the copy of pl. 324 (315) in his collection

of drawings at Kew bears a manuscript note to the effect that the spores measured $13-15 \times 10-12 \mu$.

Entoloma bulbigenum should be discarded as a name which originated in confusion.

(25) *Entoloma thomsoni* B. & Br. Notices No. 1523, Feb. 1876.

The type collection consists of four pressed sporophores mounted on two small sheets, each labelled 'Ag. (*Entoloma*) *Thomsoni* B. & Br. West Farleigh'. The largest pileus has been much deformed in pressing, the others measure 2.7, 2.5 and 2.0 cm. and the longest stipe is about 4 cm. \times 2 mm.

The surface of the pileus bears vesicular cells $20-25 \times$ about 15μ which presumably gave it the 'velvety' appearance. The spores are $7-8 (-9) \times 4-6 \mu$, broadly elliptical and yellowish under the microscope. The hymenial elements are poorly preserved but there seem to be large numbers of thin-walled, pointed, vesicular cystidia. Clearly this is not an *Entoloma* or a *Rhodophyllus* of any kind. The spores and free gills point to a *Pluteus*, almost certainly *P. cinereus* Quélet (1884) and the name should therefore be *Pluteus thomsoni* (Berk.) comb. nov.

(26) *Entoloma wynniae* B. & Br. Notices No. 1342, May 1873.

Seven specimens from the type collection of *E. wynniae* are preserved in Berkeley's herbarium, labelled 'Ag. (*Entoloma*) *wynnei* B. & Br. Coed Coch 1872 near *A. costatus*'. The largest pileus now measures 2.5 cm. in diameter, the longest stipe about 3.5 cm. \times 3 m. The surface of the pileus is formed of vesicular pyriform cells interspersed with elongated swollen brown hairs up to $100 \times 12 \mu$. The spores are of the *Rhodophyllus* type $13-17 \mu$ long, including the prominent apiculus and $6-8 \mu$ broad. No cystidia were seen.

(27) *Nolanea babingtonii* B. & Br. Notices 680, May-June 1854.

The type material labelled '*A. Babingtonii* Blox. Ag. (*Nolanea*) *Bloxami* Berk. Rev. A. Bloxam Twycross Nov. 21, 1851' is riddled by mites and consists of little more than a mass of frass. No *Rhodophyllus* spores were found and some, perhaps all, of the hair-like bodies on the cap are the brown geniculate conidiophores of a Dematiaceous mould. The Collyweston collection mentioned in Notices 903* is evidently that labelled '*Ag. Babingtonii* B. King's Cliffe, Oct. 2, 1860'. It contains two well-preserved sporophores with abundant *Rhodophyllus* spores $16-20 \times 8-10 \mu$. The surface of the pileus is composed of inflated parallel hyphae running out into rather short swollen hairs with cells some 25μ broad. Similar but longer hairs occur on the stipe. Mr Pearson thinks this is *Nolanea fumosella* (Winter) Sacc. (= *N. strigosissima* Rea).

(28) *Clitopilus sarnicus* Massee 1897, p. 22.

The type collection contains a single specimen with pileus 2.3 cm. across, conspicuously striate to the disk, with stipe 1.4 cm. \times 2 mm. It is pressed flat but the gills were apparently adnate or adnato-decurrent. There is no specialized cuticle and there are no cystidia. The spores are of the *Rhodophyllus* type, $10-12 \times 6-9 \mu$. It is apparently a form of *Clitopilus cancrinus* Fr.

(29) *Clitopilus stilbocephalus* B. & Br. Notices No. 1758, March 1879.

The type collection contains two pressed sporophores with pilei 2.5 and 2.2 cm. diameter and stipes 4.6 cm. \times 1 mm. and about 7.0 cm. \times 1.5 mm. respectively, and a vertical section showing adnate gills 3 mm. broad. There are also pen and ink sketches of a campanulate pileus and of three sections, one showing broad, deeply sinuate gills, the others adnate ones.

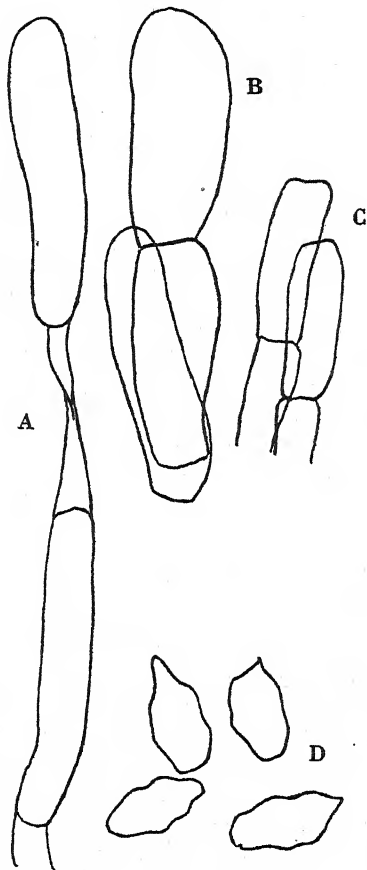


Fig. 5. *Nolanea babingtonii*. A, Hair of stipe. B, Hairs of pileus. C, Surface cells of pileus, all $\times 500$. D, Spores $\times 750$.

On the same sheet is a manuscript Latin diagnosis similar to that published with in addition 'odore non ingrati' and the note 'sparkling as in *A. atomatus*'. Cooke's pl. 349 (324) lower figures was concocted largely from these sketches. The surface of the pileus seems to be formed of radiating hyphae with nothing to suggest the reason for the atomate appearance. The spores are of the *Rhodophyllus* type, $11-13 \times 6-8 \mu$. Possibly this was *Entoloma griseocyaneum* (Fr.) Quél.

SUMMARY

Re-examination of authentic material of twenty-nine little known British Agarics lead to the following conclusions:

- (1) *Lepiota polysticta* Berk. probably equals *L. clypeolarioides* Rea.
- (2) *Armillaria jasonis* Cke. & Massee is *Lepiota amianthina* (Scop.) Fr.
- (3) *Tricholoma circumtectum* Cke. & Massee is probably *T. scalpturatum* Fr. sensu Bresadola.
- (4) *T. tenuiceps* Cke. & Massee is *T. aggregatum* (Schaeff.) Quél.
- (5) *Clitocybe obscurata* Cke. is probably a form of *C. clavipes* (Pers.) Fr.
- (6) *Laccaria nana* Massee is a distinct species correctly described by Massee.
- (7) *Hygrophorus cerasinus* Berk. is *H. agathosmus* Fr.
- (8) *H. micaceus* B. & Br. is a distinct species near *Omphalia atropuncta* (Pers.) Quél.
- (9) *Hygrophorus ventricosus* B. & Br. is a form of *H. virgineus* (Wulf.) Fr.
- (10) *Collybia eustygia* Cke. is a rooting form of *Tricholoma immundum* Berk.
- (11) *Agaricus crassifolius* Berk. is probably a member of the *Tricholoma myomyces* group.
- (12) *Collybia psathyroides* Cke. was based on diseased material and should be discarded.
- (13) *C. stevensonii* B. & Br. was probably founded on an abnormal plant and cannot at present be recognized.
- (14) *Mycena berkleyi* Massee was probably *M. galericulata* (Scop.) Fr.
- (15) *M. paupercula* Berk. is probably a good species.
- (16) *Omphalia abhorrens* B. & Br. is probably *Hygrophorus foetens* Phillips.
- (17) *Omphalia alutacea* Cke. & Massee may be distinct.
- (18) *O. telmatiaea* Berk. & Cke. must remain in doubt until the type is discovered.
- (19) *O. infumata* B. & Br. may be distinct.
- (20) *Pleurotus hobsoni* Berk. may probably be the same as *Clitopilus pleurotelloides* (Kühner) Jossierand.
- (21) *Pleurotus laurocerasi* B. & Br. is a distinct species.
- (22) *P. ruthae* B. & Br. is *Pleurotus petaloides* (Bull.) Fr.
- (23) *Pluteus spilopus* B. & Br. should be deleted from the British list of Agaricaceae. It is a good species from Ceylon.
- (24) *Entoloma bulbigenum* Berk. originated in confusion. *Agaricus personianus* Phill. probably was *Inocybe fibrosa* (Sow.) Fr.
- (25) *Entoloma thomsoni* B. & Br. is a *Pluteus*, *P. thomsoni* (B. & Br.) comb. nov., identical with *P. cinereus* Quél.
- (26) *Entoloma wynniae* B. & Br. may be a good species.
- (27) *Nolanea babingtonii* Berk. is probably the valid name for *N. fumosella* (Winter) Sacc.
- (28) *Clitopilus sarnicus* Massee is probably a form of *C. cancrinus* Fr.
- (29) *C. stilbocephalus* B. & Br. may be *Entoloma griseo-cyaneum* (Fr.) Quél.

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OBSERVATIONS ON THE NUTRITIONAL REQUIREMENTS OF *STREPTOMYCES GRISEUS* (KRAINSKY) WAKSMAN & SCHATZ

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(With Plates XII and XIII and 6 Text-figures)

INTRODUCTION

In these laboratories, the best medium for the growth of *Streptomyces griseus* and for streptomycin production by this organism has been found to be one containing mineral salts, glucose, peptone, and meat extract, described by Ainsworth, Brown, Marsden, Smith and Spilsbury (1947) as 'Belmont medium'. This paper is an attempt to outline the nutritional requirements of the organism and demonstrates that the success of Belmont medium is largely due to its mineral content and the added meat extract.

METHODS

All the experiments described below were performed at 28° C., the optimum temperature for growth as determined in these laboratories, and the strain used was the one employed for large-scale streptomycin production by Ainsworth *et al.* (1947), National Collection of Type Cultures no. 7187. The pH of all media was adjusted to 6.9 ± 0.1 before sterilization. Assay was carried out by the method of Brown and Young (1947), using *Escherichia coli* as the test organism, the results being expressed in micrograms of pure streptomycin base.

Mycelial dry weights were obtained either by collecting the mycelium and drying to constant weight in an oven at 100° C. or by freeze-drying the washed mycelia in tared aluminium receptacles.

It will be convenient to discuss the experiments in three groups; the effect of metals upon growth, the nitrogen source, and growth-factor requirements.

THE EFFECT OF METALS UPON GROWTH

Belmont medium as used for streptomycin production normally contains added iron and copper as sulphates in addition to sodium nitrate, potassium dihydrogen phosphate and magnesium sulphate. The inclusion of these substances being purely empirical it was felt desirable to investigate their several effects on the growth of the organism.

In order to obtain some basis upon which to work, a sample of dried material obtained from mycelial mats grown upon Belmont medium was submitted to spectrographic analysis by the arc method. The principal

elements detected were calcium, magnesium, sodium, silicon, iron, potassium and phosphorus, arranged in decreasing order of quantity as estimated from the intensities of the lines. A small quantity of copper was detected and also traces of aluminium, barium, strontium, lithium, rubidium, manganese and lead. The presence of zinc was doubtful.

In addition to this analysis, a further preliminary investigation was undertaken by incorporating various elements at 0.4, 2.0 and 10.0 p.p.m. concentrations in a synthetic medium containing ammonium nitrate as the nitrogen source at a level of 1 mg./ml. nitrogen together with the salts normally present in Belmont medium. The medium also contained 1 % glucose and 50 mg./ml. tryptophan. It was found that the ions of lead, tin, uranium, vanadium, cerium, strontium, chlorine, iodine and fluorine had no appreciable effect at any concentration employed. Slight stimulation of growth appeared to result from ions of bromine at 2 p.p.m., zirconium at 10 p.p.m., and all concentrations of molybdenum employed, which latter result was independently confirmed by Miss E. Brookfield in these laboratories. Bismuth and lithium were slightly toxic at 2 p.p.m., aluminium, cobalt and nickel were toxic at 10 p.p.m. (also confirmed by Miss Brookfield), while cadmium proved to be extremely toxic at all concentrations employed. From the above data it was considered that the metals most likely to prove worthy of investigation were copper, iron, manganese, zinc and molybdenum, together with the major salt constituents. It is noteworthy that copper, manganese and zinc are recognized to be important in penicillin production by certain strains of *Penicillium notatum* and *P. chrysogenum*, that manganese has been shown by Robbins and Hervey (1944) to be essential to the growth of *Pythiomorpha gonapodyides*, and that molybdenum has been shown by the author (unpublished data) to affect the sporulation of *Penicillium notatum*, strain N.R.R.L. 1249 B21, when added to Moyer's glycerol molasses medium. There are also numerous references in the literature to the effect of these metals on the nutrition of fungi (see Stiles, 1946), but none as far as could be ascertained with respect to actinomycetes.

The effect of copper, iron, manganese and zinc in Belmont medium

The first experiment consisted of adding copper, iron, manganese and zinc as 'Analar' hydrated sulphates to Belmont medium from which the copper and iron had been omitted. They were added singly at concentrations of 50 and 10 p.p.m. of metal and in all possible combinations at 10 p.p.m., a control being left without any trace metal addition. The media were distributed in 200 ml. quantities in pint milk bottles, the necks of which were closed with aluminium caps as described by Ainsworth *et al.* (1947). The bottles were sterilized, inoculated from a suspension of *Streptomyces griseus* grown upon normal Belmont medium, and sloped. From the commencement of growth there were noticeable differences in the appearance of the growths resulting from different treatments. On the third day after inoculation the control bottle was completely covered by a whitish growth. 50 p.p.m. copper resulted in a thicker growth with a

tendency to greyish appearance. 50 p.p.m. of zinc were inhibitory, the surface growth consisting of small scattered brownish colonies, while much of the growth consisted of sphaeroidal submerged colonies similar to those normally obtained in shaken cultures in conical flasks. The effects of manganese and iron were similar to that of copper, except that in the case of iron the growth was definitely brownish. Concentrations of 10 p.p.m. copper, manganese and iron resulted in growth of a heavier nature than the control or with the same metals at 50 p.p.m. Zinc at 10 p.p.m. did not cause such abnormal growth as at the higher concentration, but the appearance of the mycelium was whitish and granular. Mixtures of the metals tended to give an intermediate appearance; thus mixtures containing zinc possessed a tendency to granular growth, those containing iron to become brown, and those containing copper or manganese to become thicker, wrinkled and grey. It may be noted that the brown coloration obtained in this experiment was identical in appearance with that obtained by incubation at a temperature in excess of the optimum (Ainsworth *et al.* 1947) and was due to the waterlogging of the mycelium with the medium and not to any morphological change in the hyphae. This phenomenon appears to be intimately connected with the metabolism of the mould; its reversibility with regard to temperature has been demonstrated, and it seems likely that a change in the constituents of the medium alters the optimum temperature for the production of aerial mycelium. The grey coloration obtained in this experiment resulted from free sporulation of the organism which might or might not precede the formation of a brown mycelial mat. The white, granular appearance is typical of the vegetative phase of the organism on semi-solid media such as that of LePage and Campbell (1946). Good growth obtained in the control of this experiment cannot be interpreted as an indication that these trace metals are inessential to growth, since such elements would undoubtedly be added in the peptone and meat extract, and, indeed, the only interpretation possible is that of the gross effect of further additions of trace metals added to a medium already containing a sufficiency of them to permit adequate growth. The spectrographic analysis of the organism confirms that copper and manganese are absorbed from the media and therefore probably possess some physiological function; the submerged growth resulting from zinc treatment indicates that this metal at least has a marked effect on the general physiology of the actinomycete, and the data obtained show that the trace metals present have a definite effect on both the amount of mycelium obtained and the titre of streptomycin produced therefrom. The titre, pH and mycelial dry weights of the cultures are presented, together with their analysis of variance in Table 1, and the effects of the trace metals on titre and mycelial dry weight are represented diagrammatically after the method of Richards (1941) in Text-figs. 1 and 2.

The general conclusions to be drawn from the data are that the presence of copper definitely increases the titre, the optimum concentration in the Belmont medium lying between 10 and 15 p.p.m. of added metal. Manganese has a slighter but still significant effect, and zinc decreases the titre.

The best combination for streptomycin production appears to be copper-manganese mixture. Copper definitely antagonizes the bad effect of zinc. The combinations of manganese with iron and of zinc with iron would be expected to be bad, judging from their main effects, and fulfil expectation. Data of a similar nature were obtained after 12 days' growth, and although not complete, they substantiate the above findings. In general, it was observed in this experiment that factors tending to good titre also gave the highest pH values. This experiment was repeated with similar results.

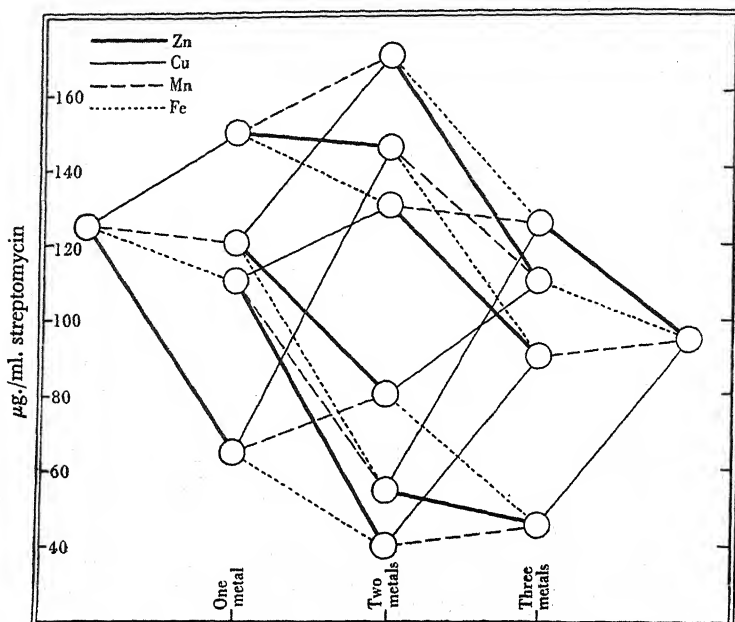
Table 1. *Effect of trace metals on growth, titre and pH. The data presented are the result of bulking three bottles from each treatment*

Treatment	7 day							12 day	
	Dry wt.	t	Probability	µg./ml.	t	Probability	pH	pH	µg./ml.
Control	2.51	—	—	125	—	—	7.16	7.70	100
Copper, 50 p.p.m.	4.64	—	—	80	—	—	7.41	8.00	130
Copper, 10 p.p.m.	4.32	6.38	0.1-0.05	150	14.99	0.05-0.02	7.59	8.10	100
Zinc, 50 p.p.m.	0.94	—	—	—	—	—	7.24	7.50	20
Zinc, 10 p.p.m.	1.41	—	—	65	12.59	0.1-0.05	7.27	7.70	15
Manganese, 50 p.p.m.	0.98	—	—	115	—	—	7.20	7.00	—
Manganese, 10 p.p.m.	2.77	—	—	120	10.99	0.1-0.05	7.06	7.60	—
Iron, 50 p.p.m.	1.58	—	—	115	—	—	6.88	7.05	—
Iron, 10 p.p.m.	2.29	—	—	110	—	—	7.02	7.70	70
Cu x Zn	2.84	—	—	145	—	—	7.06	8.10	150
Cu x Mn	3.71	—	—	170	—	—	7.35	8.00	130
Cu x Fe	4.10	—	—	130	—	—	7.25	8.20	200
Mn x Zn	1.72	—	—	80	—	—	7.24	7.00	—
Zn x Fe	1.32	—	—	40	—	—	7.10	—	—
Mn x Fe	2.25	—	—	55	—	—	7.20	7.30	—
Cu x Zn x Fe	4.26	—	—	90	—	—	7.19	8.15	—
Cu x Fe x Mn	4.06	—	—	125	—	—	7.46	8.25	200
Fe x Mn x Zn	1.90	—	—	45	4.19	0.2-0.1	7.16	7.70	50
Cu x Mn x Zn	3.59	—	—	110	5.00	0.2-0.1	7.25	8.10	110
All metals (error)	3.79	—	—	95	—	—	7.20	8.10	110

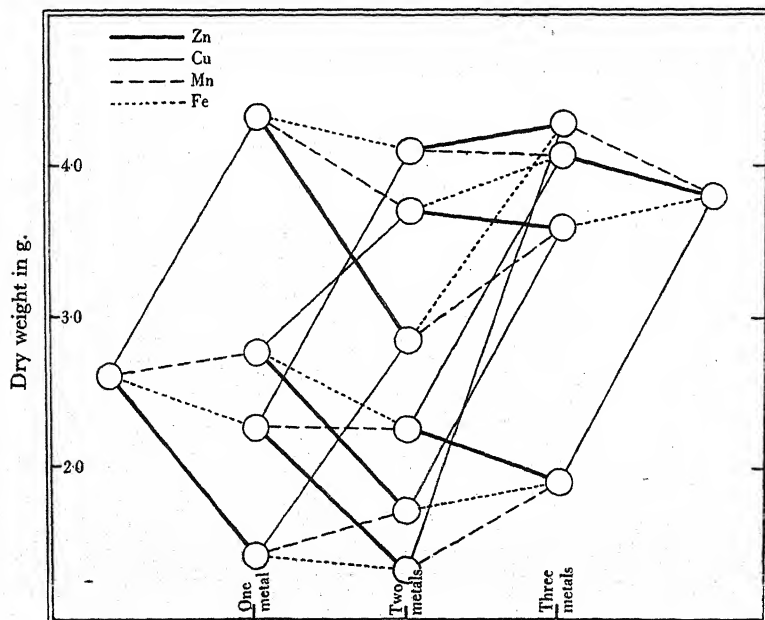
The effect of copper, manganese and molybdenum

The next experiment was concerned with evaluating the effect upon growth of different concentrations of copper and manganese and also of molybdenum, for reasons previously mentioned. A modified Belmont medium was devised in which the peptone was replaced by 'Pronutrin' casein hydrolysate (Herts Pharmaceuticals Ltd.) of equivalent nitrogen content and to which 0.001 % tryptophan was added. The resulting medium was much paler in colour than Belmont medium, so that the observation of pigment production was facilitated. Copper and manganese were added in the same form as previously used at the rate of 0, 2, 4, 8, 16, 32 and 64 p.p.m. and molybdenum at 0, 2 and 4 p.p.m. as sodium molybdate, 'Analar'. These additions were made in all possible combinations. The media were dispensed in 10 ml. quantities in 50 ml. Pyrex conical flasks. Inoculation was from a suspension of washed spores grown on normal Belmont medium.

Observations were made on the growth after 7 days' incubation and on the material harvested after 10 days' growth. The amount of surface growth

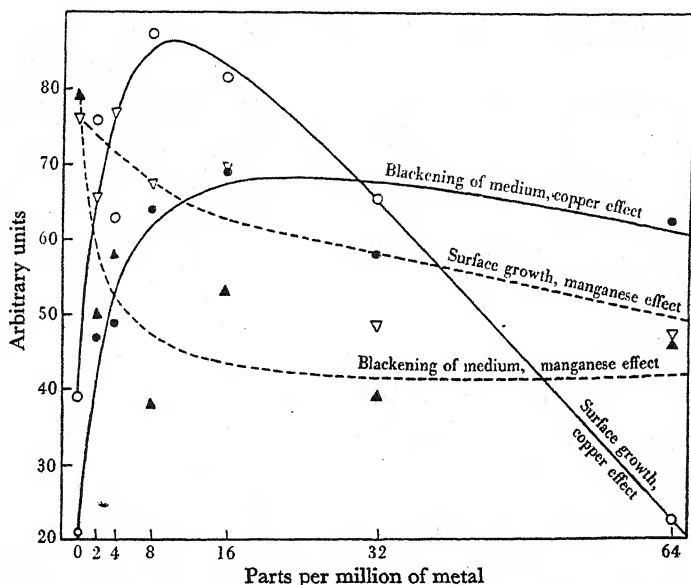


Text-fig. 1. The effect of trace-elements on streptomycin titre in Belmont medium. Control, extreme left; full treatment, extreme right.



Text-fig. 2. The effect of trace-elements on mycelial dry-weight in Belmont medium. Control, extreme left; full treatment, extreme right.

and the degree of darkening of the medium, as recorded in purely arbitrary units, is illustrated in Text-fig. 3. No significant difference could be detected due to different molybdenum content, and the curves shown are therefore compounded for three observations for each point represented. It is obvious that both copper and manganese, but especially the former, had a marked effect on coverage, which was more than doubled by the addition of the optimum concentration of copper (*c.* 8 p.p.m.) to the control lacking the added metal. Increasing the addition of copper above this level resulted in a return to poorer coverage. The manganese effect was opposite to that of copper, increasing its concentration resulting in poorer coverage. Darkening of the medium was noticeably affected by



Text-fig. 3. The effect of copper and manganese on surface growth and pigment production in a casein hydrolysate medium.

both metals. In the absence of copper it retained its original colour, but the addition of increasing quantities of copper resulted in progressive darkening of the medium until with concentrations greater than 8 p.p.m. it became almost black. Again the manganese effect was directly opposite, its absence resulting in the maximum manifestation of the effect due to copper and increase of its concentration resulting in a progressively paler coloured fluid. Assuming that the darkening of the medium is correlated with some oxidase activity of the organism it seems likely that the copper and possibly the manganese play some role in the elaboration or physiological function of such an enzyme as has already been demonstrated in the mushroom by Keilin and Mann (1938). The mycelial dry weights are given in Table 2, and Text-fig. 4 shows the main effects of the metals plotted separately. Their statistical significance is apparent from Table 3.

Table 2. *Effect of trace metals in a casein hydrolysate medium. 10 days' growth. Mycelial dry weights in mg.*

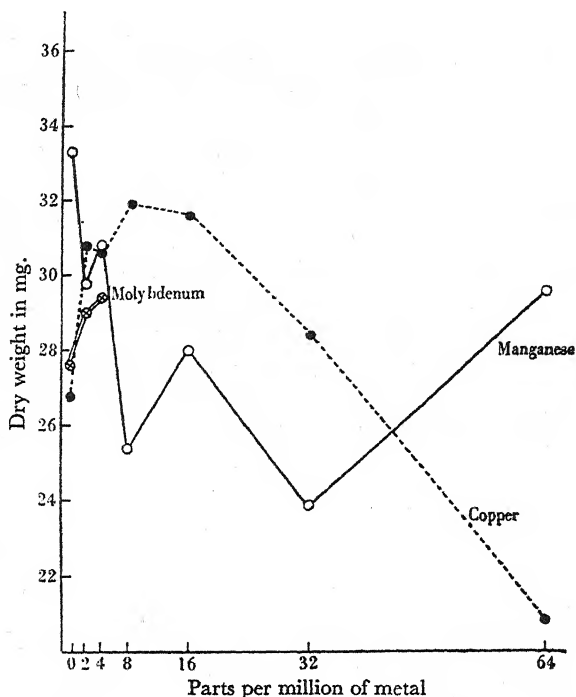
— indicates negligible growth.

Added copper concentrations (p.p.m.)	Added manganese concentration (p.p.m.)						
	0	2	4	8	16	32	64
	Molybdenum absent						
0	23.5	31.1	31.1	27.0	34.2	21.6	29.4
2	40.9	26.3	33.2	35.1	27.0	33.4	28.3
4	33.7	33.0	29.9	32.1	32.7	33.9	23.8
8	33.6	28.5	34.0	33.3	32.6	33.9	31.9
16	46.3	35.1	34.5	33.2	32.0	36.4	32.9
32	34.1	39.9	31.0	—	—	17.5	38.4
64	42.6	33.4	—	—	—	—	—
	Added molybdenum 2 p.p.m.						
0	25.0	25.3	26.8	28.9	23.8	27.9	22.5
2	34.1	17.8	31.2	34.2	29.4	29.7	29.6
4	35.3	33.5	34.0	30.7	26.7	24.0	33.1
8	34.3	31.6	33.5	30.9	31.3	19.6	39.2
16	26.9	36.4	32.8	35.8	33.8	—	28.4
32	29.5	22.7	29.8	27.4	31.4	32.3	32.0
64	33.9	33.0	16.6	39.2	28.4	27.6	18.8
	Added molybdenum 4 p.p.m.						
0	19.7	17.8	44.1	22.2	25.4	28.4	26.2
2	32.9	32.9	36.7	16.9	38.3	30.3	27.1
4	33.2	30.9	35.2	27.9	34.3	8.9	36.7
8	36.1	33.3	34.1	32.1	25.1	33.2	28.7
16	33.7	32.1	30.7	28.2	33.6	26.1	35.3
32	33.7	40.6	30.3	18.7	35.0	37.3	35.1
64	36.5	11.3	38.3	—	34.1	—	43.2

Table 3. *Analysis of variance of mycelial dry weights of Streptomyces griseus grown on casein-hydrolysate medium with different trace-metal concentrations*

	Sum of squares	Degrees of freedom	Variance	Variance ratio	Probability
Main effects:					
Copper	1956.64	6	326.10	3.11	0.01
Manganese	1303.03	6	217.17	2.07	0.05
Molybdenum	100.15	2	50.07	—	—
First order interactions:					
Cu × Mn	1407.06	36	39.08	—	—
Cu × Mo	241.37	12	20.11	—	—
Mn × Mo	1380.18	12	115.01	1.10	0.2
Second order interaction (error)	7537.43	72	104.68	—	—

These data confirm the observations that copper, and, to a lesser extent, manganese are of significance in the development of the mycelial mat. Assays of streptomycin activity on selected crude filtrates from this experiment tended to confirm that the best titres were obtained with 8-16 p.p.m. copper and an equivalent amount of manganese.



Text-fig. 4. The effect of copper, manganese and molybdenum on mycelial dry weights on casein hydrolysate medium.

The effect of the nitrogen source on the action of trace metals

Since it was apparent from the two preceding experiments that the growth of the organism was less vigorous upon 'Pronutrin' than upon peptone, and that growth was modified in each case by the trace-metal content of the medium, it was thought desirable to devise an experiment to determine whether the nitrogen source modified the trace-metal effect. Belmont medium base was utilized, with the addition of 0.005% tryptophan and 0.00245% cystine, the nitrogen being supplied from various sources at the rate of 1 mg./ml. The growth of *Streptomyces griseus* on these media after 7 days' growth is expressed in arbitrary units in Table 4. It will be noted that in some cases growth was very poor when copper and manganese were added, whilst in others good growth was obtained, and it is likely that, since no steps were taken to remove trace metals from the media, they were actually present in some of the nitrogen sources in sufficient

quantity to permit growth to take place. Photographs of part of the experiment are shown in Pls. XII and XIII, and it will be noticed that the appearance of the mycelium is markedly influenced by both the nature of the nitrogen source and the concentration of trace metals added.

Two facts are evident from this experiment: that the tolerance of the organism for copper and manganese is largely dependent upon the nature of the nitrogen source, and that there is in every case an optimum concentration of the trace metals for growth. This latter is more easily noted in Pls. XII and XIII, which were taken when the cultures were 10 days old, than

Table 4. *Growth of Streptomyces griseus on different nitrogen sources with differing trace-metal concentrations. 7 days' growth*

+ indicates amount of growth, t.=trace, st.=slight trace, —=no growth.

Nitrogen source	Added Cu and Mn concentration (p.p.m.)						
	0	2	4	8	16	32	64
Glycine	++++	++++	++++	++++	++++	++++	+++
'Casydrol'	++++	++++	++++	++++	++++	++++	+
Peptone	+++	+++	+++	+++	+++	+++	+
Asparagin	+++	+++	+++	+++	+++	++	+
Ammonium nitrate	+++	+++	+++	+++	st.	—	—
Ammonium chloride	+	++	++	++	+	t.	st.
Ammonium sulphate	++	++	++	++	+	—	—
Glycocyamine	+	++	+	+	+	+	t.
Guanidine	+	+	t.	t.	st.	—	—
Creatin	t.	+	t.	t.	—	—	—
Potassium nitrate	t.	t.	t.	t.	st.	—	—

in Table 4. The increased tolerance of the organism towards trace metals in such media as those containing amino-acids and asparagin suggests that, in these media, the copper and manganese is combined in organic form and is not active as a toxic cation. This toxicity is most readily observed in the presence of ammonium salts and other sources of nitrogen not readily available to the actinomycete.

The major mineral constituents

The effect of the so-called trace elements having been demonstrated it remains to discuss the effect of the major mineral nutrients. The empirical combination of mineral salts in Belmont medium had resulted in a medium superior in streptomycin and growth-producing properties to other media examined, and the following experiment was designed to assess the value of the different salts employed and to supply information relating to the nitrogen source and certain growth factor requirements, which will be discussed below.

The experiment was designed factorially, using 1 % glucose as the carbohydrate source, and incorporated two nitrogen sources, 'Pronutrin' casein hydrolysate and asparagin at a nitrogen level of 1 mg./ml.; 0.001 % tryptophan and 0.001 % cystine, and a control lacking these growth factors; 10 p.p.m. copper and manganese as 'Analar' sulphates and a

control; three growth-promoting natural extracts and a control, and the following combination of mineral salts:

- (a) Control, no salts added.
- (b) NaNO_3 , 0.4 %.
- (c) KH_2PO_4 , 0.1 %.
- (d) MgSO_4 , 0.05 %.
- (e) $\text{NaNO}_3 + \text{KH}_2\text{PO}_4$, concentrations as above.
- (f) $\text{NaNO}_3 + \text{MgSO}_4$, concentrations as above.
- (g) $\text{KH}_2\text{PO}_4 + \text{MgSO}_4$, concentrations as above.
- (h) $\text{NaNO}_3 + \text{KH}_2\text{PO}_4 + \text{MgSO}_4$, concentrations as above.

Because of the large size of the experiment the usual receptacles were abandoned and the media were distributed in 10 ml. quantities in 25 ml. glass bottles with narrow necks. After inoculation in the usual way the bottles were sloped so that as large an area as possible of the medium was exposed on which growth could take place.

Growth observations were made at intervals, and after 10 days' growth the material was harvested and the mycelial weights obtained. The beneficial effect of copper and manganese on the appearance of the growth was again confirmed, the presence of these metals giving a better surface growth than the control. Thick white growth was especially noticeable on the casein hydrolysate medium in the presence of phosphate and magnesium. Absence of the trace metals resulted in a pronounced slimy and submerged growth on 'Pronutrin' and, to a much lesser extent, on asparagin. On the latter medium the effect of the trace metals was to produce a grey and scaly growth rather than a white and powdery one. Very little growth took place in the absence of mineral salts. The presence of sodium nitrate alone resulted in a slight toxicity which was removed by phosphate and magnesium sulphate, particularly in combination. These latter were also stimulatory to surface growth together, but not singly. The appearance of all these combinations was influenced by the nature of the extract added and resulted in a great variety of growth forms. Some of these forms had already been observed on batches both of Belmont medium and some other media developed by Ainsworth *et al.* (1947).

The mycelial dry weights are presented in Table 5, with their analysis of variance in Table 6, and it will be seen that the effect of the mineral constituents on dry weight is similar to that on growth as judged by coverage and appearance, and is highly significant when compared with other factors. This experiment emphasizes the need for a well-balanced medium with respect to all the factors, for the optimum development of *S. griseus*.

The nitrogen source

The organism appeared to be able to utilize a wide range of nitrogenous material, and many experiments were conducted in these laboratories in an endeavour to discover a suitable substitute to peptone in Belmont medium with varying degrees of success. It has already been shown (Table 4) that the best sources of nitrogen for growth appear to be

substances possessing amino groups, and that nitrates, ammonium salts, and nitrogen in cyclic molecules are less readily available. In addition to the substances listed above, aspartic and glutamic acids and glutamine provide a substrate suitable for normal growth. It must be emphasized that the availability of any particular substrate depends upon the presence and adequate concentration of the necessary mineral nutrients and growth factors.

In the experiment detailed in Tables 5 and 6 it is shown that 1 mg./ml. nitrogen as casein hydrolysate gives a greater weight of mycelium than an

Table 5. *Weights of freeze-dried mycelium from different media (expressed in mg.)*

	Without added Cu and Mn				Added Cu and Mn (10 p.p.m. each)			
	'Pronutrin'		Asparagin		'Pronutrin'		Asparagin	
	Control	+ Tryp- tophan and cystine	Control	+ Tryp- tophan and cystine	Control	+ Tryp- tophan and cystine	Control	+ Tryp- tophan and cystine
No salts, no extract	7.0	21.5	6.1	0.4	7.9	17.8	5.1	0.8
1 % meat	13.1	20.6	12.6	20.6	12.8	2.2	5.1	15.9
1 % yeast	17.4	26.1	14.2	15.4	14.8	15.6	11.9	16.9
1 % dung	12.4	22.0	12.3	7.9	15.2	15.2	5.4	8.8
NaNO ₃ , no extract	7.0	23.0	1.4	16.8	13.9	13.8	1.4	0.5
1 % meat	22.0	21.8	8.2	25.5	14.2	17.2	19.0	24.9
1 % yeast	22.5	21.2	6.6	15.3	15.0	20.9	18.2	14.9
1 % dung	12.4	23.3	6.9	10.0	19.7	5.2	13.6	10.5
KH ₂ PO ₄ , no extract	11.8	20.0	0.9	0.4	22.7	19.4	3.3	10.4
1 % meat	17.9	20.5	9.2	26.6	27.4	23.8	20.1	21.4
1 % yeast	24.8	22.9	10.1	19.9	19.4	24.0	15.8	18.6
1 % dung	19.4	26.5	12.0	24.6	19.5	25.6	12.0	21.7
MgSO ₄ , no extract	17.7	10.8	6.4	11.8	3.6	4.2	13.1	8.8
1 % meat	22.2	13.2	27.2	25.9	16.2	15.8	11.8	14.7
1 % yeast	37.3	25.7	25.8	16.9	13.1	13.0	12.6	12.5
1 % dung	12.4	22.6	24.5	8.6	10.5	8.5	10.3	7.1
NaNO ₃ + KH ₂ PO ₄ , no extract	17.1	16.1	6.4	7.6	31.5	15.9	13.1	30.6
1 % meat	18.4	18.0	19.9	20.8	27.4	20.9	32.4	25.2
1 % yeast	24.9	12.3	8.0	9.2	25.2	18.6	27.6	35.0
1 % dung	21.3	14.0	7.8	8.3	27.8	26.1	26.6	12.9
NaNO ₃ + MgSO ₄ , no extract	31.2	30.0	6.9	10.8	6.6	9.0	22.8	16.4
1 % meat	28.1	24.1	21.9	24.8	12.9	49.0	27.9	33.3
1 % yeast	24.1	20.4	22.5	20.8	24.0	38.2	11.4	19.7
1 % dung	30.9	21.2	18.0	8.5	23.2	28.2	16.9	11.5
KH ₂ PO ₄ + MgSO ₄ , no extract	22.3	21.9	25.7	31.2	24.0	22.5	14.0	14.1
1 % meat	22.7	14.7	22.2	25.0	10.6	22.2	22.2	20.5
1 % yeast	24.9	20.6	17.3	18.5	25.4	18.0	17.3	17.5
1 % dung	28.8	18.0	20.4	21.5	30.3	22.0	30.9	20.3
All salts, no extract	39.7	8.8	23.0	20.5	30.3	20.7	23.2	25.2
1 % meat	22.2	15.6	32.3	37.5	33.0	26.8	24.6	25.0
1 % yeast	23.0	17.2	24.3	25.8	31.1	30.6	20.7	25.8
1 % dung	51.7	17.2	19.5	14.4	28.5	41.4	19.5	29.7

Table 6. *Analysis of variance on data in Table 5*

Treatments	Sum of squares	Degrees of freedom	Mean square	Variance ratio	Probability
Main effects					
A (Nitrogen source)	965.65	1	965.65	6.54	0.05-0.01
X (Trace metals)	1.29	1	1.29	—	—
α (Tryptophan and cystine)	9.92	1	9.92	—	—
a (Mineral constituents)	4405.99	7	629.43	5.60	0.001
i (Growth factors)	1440.24	3	480.08	3.24	0.05-0.01
First-order interactions					
AX	91.61	1	91.61	—	—
AI	727.06	3	242.35	1.64	> 0.2
A α	119.37	1	119.37	—	—
Aa	374.81	7	53.54	—	—
X α	14.74	1	14.74	—	—
Xa	1663.53	7	236.66	1.60	> 0.2
Xi	15.57	3	5.19	—	—
α i	142.29	3	47.43	—	—
αa	636.94	7	90.99	—	—
aI	1074.14	21	51.15	—	—
Second-order interactions					
Xia	368.46	21	17.55	—	—
Xi α	55.33	3	18.44	—	—
Xaa	827.77	7	118.25	—	—
αa i	651.06	21	31.00	—	—
AX α	21.27	1	21.27	—	—
AXi	52.43	3	17.48	—	—
Axa	286.61	7	40.94	—	—
A α i	45.64	3	15.21	—	—
Aaa	552.34	7	78.91	—	—
Aai	592.02	21	28.19	—	—
Third-order interactions					
XAaa	3094.92	7	43.56	—	—
XA α i	27.67	3	9.22	—	—
Xaia	548.04	21	26.10	—	—
AXia	77.45	21	51.31	—	—
A α ia	427.48	21	20.36	—	—
Error					
AX αa i	3118.15	21	148.01	—	—

equivalent concentration of nitrogen as asparagin; yet there is no question that both are utilized by the actinomycete, and the evidence from this and from data presented below suggests that the most readily available nitrogen is that in amino groups.

The effect of utilization of pure amino-acids as the nitrogen source as compared with ammonium nitrate is illustrated in Table 7. Belmont medium was used in which the peptone was replaced by 1 mg./ml. nitrogen as indicated in Table 7 and to which 0.008 % tryptophan was added. The experiment was carried out in quadruplicate with regard to nitrogen source, there being a control and sections incorporating 0.001 % concentrations of creatine, guanidine hydrochloride, and inositol which were added as possible growth factors. Actually they affected neither

growth nor titre, and the assay figures and the growth notes are therefore the means of four observations. For growth, straight-chain acids were better than those with branched chains, the very noticeable exception being histidine. The amide of the dicarboxylic glutamic acid is better than the monocarboxylic acids, and the only one giving growth comparable with ammonium nitrate. Branched chain acids gave weaker and browner growth and those containing the benzene ring very poor growth. Methionine was too toxic to permit growth, and was comparable in this respect with cystine. For streptomycin production the straight-chain acids were the best, but the branched chain ones gave higher titres than would be expected from the feeble growth produced. Histidine and glycine give

Table 7. *The effect of different amino-acids on growth and streptomycin titre*

Nitrogen source	Growth at 7 days	Titre at 7 days ($\mu\text{g./ml.}$)
Ammonium nitrate	Good coverage	100
Glutamine	Mycelium white with a mealy appearance	38
Histidine	Medium to good coverage, but mycelium tends to become brownish	20-30
Glycine	" "	20-30
Alanine	" "	60-70
Proline	Coverage decidedly poor, mycelium scanty and brownish	18-20
Leucine	" "	18-20
Valine	" "	30
Isoleucine	" "	30
Tyrosine	" "	16
Arginine	Very poor growth, mostly submerged	18-20
Phenylalanine	" "	16
Methionine	Toxic; growth nil	0

unexpectedly low titres, and also the titre for glutamine was less than that for alanine. Acids containing benzene rings, as would be expected, gave the lowest titres.

Several points of importance emerge from the above data. Organic nitrogen is not necessary for streptomycin production; nevertheless, with some organic nitrogen sources streptomycin can be produced even when the quantity of mycelium present is small. It has been shown that, in general, assuming trace metals to be in adequate concentration the titre follows closely upon the mycelial weight, and the conclusion can be reached that the Belmont medium owes its superiority over other media tested to its balance between the amino-acids of the peptone or papain digest and its mineral constituents. It is also obvious that different amino-acids fulfil different functions within the organism; for example, glutamic acid forms a good source of nitrogen for mycelium building, alanine favours streptomycin production although not promoting good surface growth, and tryptophan, as will later be shown, is important in the initiation of growth.

Growth-factor requirements

It was early realized from experimentation on modifications of the Belmont medium that the omission of meat extract resulted in considerably poorer growth by the organism with corresponding loss of titre, and also that excessive autoclaving of this medium was deleterious to growth and could even result in complete failure of the inoculum to germinate. Several experiments were conducted with a view to ascertaining whether any accessory factors were necessary to the organism for its healthy growth in addition to the nutrients already mentioned.

Tryptophan, known already to be essential to the development of *Corynebacterium diphtheriae* from the work of Mueller (1935) and others, was suggested as a possible requirement for *Streptomyces griseus* by poor growth on acid-hydrolysed nitrogenous material and the dying out of the organism on repeated subculturing on the asparagin medium of LePage and Campbell (1946). An experiment was arranged in which the relatively impure casein hydrolysate, 'Pronutrin', and pure 'vitamin-free' casein hydrolysate (supplied by Ashe laboratories) were used as the nitrogen sources and to which tryptophan and cystine were added at the rate of 50 and 0.1 mg./ml., respectively. The scope of the experiment was further extended by the addition of 5 % extracts of meat and yeast and an extract obtained by heating 500 g. of fresh horse dung with 1 l. of water with constant mechanical stirring for $\frac{1}{2}$ hr. at 80° C., filtering through glass-wool to remove the large particles and candling. This extract was dark brown in colour and will subsequently be referred to as 'dung extract'. These various extracts were added at nine concentrations commencing at 10 % v/v of medium and halving the concentration at each level. This medium was distributed in 10 ml. portions in 50 ml. 'Pyrex' conical flasks, all the precautions customary when dealing with substances of a vitamin-like nature being observed in both this and all experiments subsequently described under this section. Inoculation was with 0.1 ml. of a washed spore suspension in 1/10,000 'Calsolene' from a slope culture on LePage and Campbell's medium. Growth after 10 days' incubation is recorded in arbitrary units in Table 8. It will be readily observed that on 'vitamin-free' casein hydrolysate medium no growth took place in the absence of tryptophan and cystine, and that there was no factor in either of the extracts employed capable of replacing these substances. In the presence of both tryptophan and cystine, good growth was obtained, the amount of growth depending on the added extract as seen in Table 8. With 'Pronutrin' growth was obtained without added tryptophan and cystine, although it was of a submerged character and a true mycelial mat was not formed as on the previous medium with these additions. On adding these substances to the 'Pronutrin' medium growth was greatly enhanced. The mycelial dry weight of some of the treatments is shown in the histogram in Text-fig. 5. It may be concluded that tryptophan and cystine or one of these substances is important for the growth of *S. griseus*, and that some factor or factors present in extracts of meat, yeast and dung result in

Table 8. *The effect of tryptophan and cystine and various natural extracts on the growth of Streptomyces griseus on casein-hydrolysate media. 7 days' growth*

t.=trace, st.=slight trace, —=no growth.

	% extract added (v/v)	Meat extract	Yeast extract	Manure extract
Vitamin free casein hydrolysate	Control	—	—	—
	10.00	—	—	—
	5.00	—	—	—
	2.50	—	—	—
	1.25	—	—	—
	0.62	—	—	—
	0.31	—	—	—
	0.15	—	—	—
	0.07	—	—	—
	0.03	—	—	—
Vitamin free casein hydrolysate + tryptophan and cystine	Control	++	++	++
	10.00	st.	t.	++++
	5.00	t.	++++	++++
	2.50	++	++	++
	1.25	++++	+++	++
	0.62	+++	+++	++
	0.31	+++	+++	++
	0.15	+++	++	++
	0.07	t.	t.	++
	0.03	++	++++	++
Pronutrin*	Control	++	++	+
	10.00	—	—	+
	5.00	—	—	+
	2.50	—	st.	+
	1.25	st.	t.	+
	0.62	t.	+	++++
	0.31	+	+	+++
	0.15	++	+	+
	0.07	++	++	+
	0.03	++	++	+
Pronutrin + tryptophan and cystine	Control	+	++	++
	10.00	+++	+++	+++
	5.00	++++	+++	+++
	2.50	++++	+++	+++
	1.25	+++	+++	+++
	0.62	+++	++	++
	0.31	++	++	++
	0.15	++	++	++
	0.07	+	++	++
	0.03	+	++	++

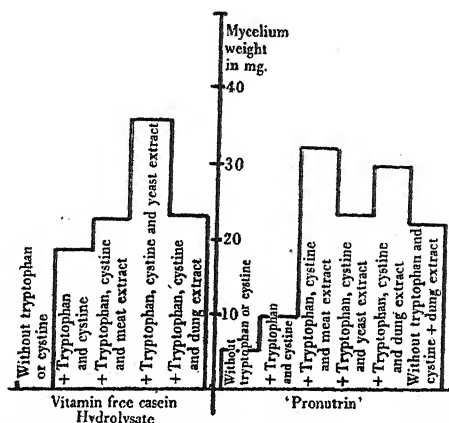
* All growth in this section was of the submerged type.

improved growth. The small amount of tryptophan and cystine possibly present in 'Pronutrin' appears to be sufficient to permit growth but not of a normal character, and it is interesting to speculate whether this effect is in any way comparable with the submerged growth resulting from the unbalanced mineral nutrition which has previously been discussed.

The need for tryptophan has also been demonstrated on a medium containing ammonium nitrate as the sole nitrogen source. It has also been found possible to replace tryptophan by a mixture of alanine and indole-3-butyric acid, and slight growth took place using alanine alone, although

this may have been due to a small amount of tryptophan present in the alanine as an impurity. The effect of these substances are illustrated in Pl. XIII. This is of interest as suggesting that *S. griseus* is able to synthesize the indole ring but is apparently unable to synthesize aminopropionic acid when provided with an inorganic nitrogen source, but it fails to explain the complete absence of growth on vitamin-free casein hydrolysate medium and further work is required to elucidate this point.

An experiment was also carried out to demonstrate the effect of tryptophan, cystine and dung extract upon growth when the nitrogen was



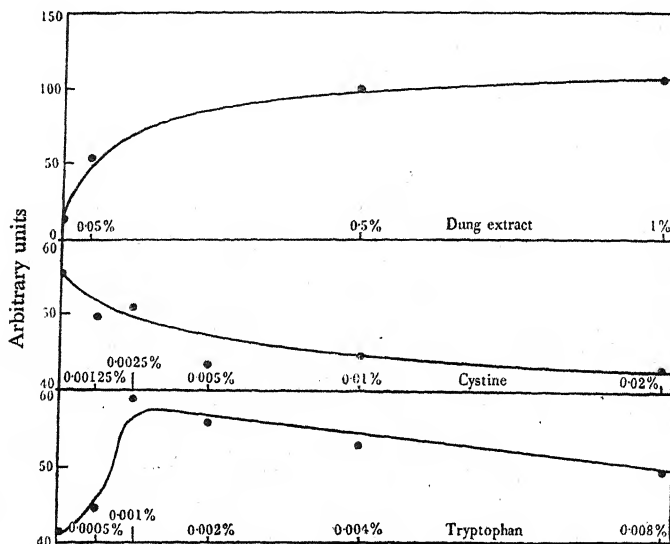
Text-fig. 5. The effect of various growth factors on mycelial dry weight on casein hydrolysate medium: 10 days.

supplied as asparagin. It should be explained that the asparagin used was from a natural source and probably contained a small quantity of tryptophan. The asparagin was incorporated in a basic Belmont medium at 1 mg./ml. total nitrogen, and the following levels of substances were added factorially:

	Percentage					
Tryptophan (w/v)	0.008	0.004	0.002	0.001	0.0005	0.0
Cystine (w/v)	0.02	0.01	0.005	0.0025	0.00125	0.0
Dung extract (v/v)	1.00	0.5	0.05	0.0	—	—

The main effects of these treatments are plotted as arbitrary units based on 2 days' growth in Text-fig. 6, and it is seen that coverage is greatly increased by 0.001 % tryptophan and 0.5 % dung extract. Increasing quantities of cystine inhibited good surface growth. As growth proceeded the differences between the treatments became less apparent. It was found that there was no significant difference in weight at different tryptophan levels after 10 days' growth, and it would seem that tryptophan is only required in the earlier stages of growth. This was borne out by general observations made on other experiments. For example, when large inocula were used, sufficient tryptophan seemed to be carried over into the experi-

mental medium from the inoculum either in the inoculum medium or the mycelium itself to permit inauguration of effective growth, a phenomenon similar to that encountered in yeast by Wildiers (1901), whereas when small inocula were employed and care was taken to use spores which had been carefully washed, growth did not proceed on media lacking tryptophan. Thus in the experiment quoted above relating to the synthesis of tryptophan it appears likely that there was sufficient tryptophan present to initiate slight growth, since a very small growth took place in the control



Text-fig. 6. The effect of tryptophan, cystine and dung extract on surface growth: 2 days. Asparagin used as the nitrogen source.

lacking added tryptophan and alanine. The depressing action of cystine and the stimulatory effect of dung extract were, however, reflected in the mycelial dry weights.

To sum up, it has been shown that tryptophan is required during the early period of growth from the spore, that cystine is not essential and proves inhibitory in quite small concentrations, and that there are certain unidentified factors present in extracts of meat, yeast and horse dung which are valuable auxiliaries to a healthy growth. According to Schopfer (1943) little seems to be known of the growth factors required by actinomycetes. It was suspected that creatine, guanidine, or inositol might act as growth factors, but tests on these substances proved negative. Other substances investigated in low concentration by Miss E. Brookfield, of a type known to influence growth in higher plants were indole-3-acetic acid indole-3-butyric acid, and naphthaleneacetic, naphthoxycetic, phenoxyacetic, 2, 4, dichlorophenoxyacetic and 2, 4, dichloropropionic acids. These had either no effect on growth or a depressing one.

SUMMARY

Evidence is presented relating to the essential constituents of a medium for optimum growth of *Streptomyces griseus* in surface culture and the production of streptomycin by this organism.

A comparison between various inorganic and organic sources of nitrogen is made with glucose as the carbohydrate source, and observations relating the growth on these substrata with the mineral nutrition of the organism are included. Various trace elements are demonstrated to be important, notably copper, manganese and zinc; and the addition of sodium nitrate, potassium phosphate and magnesium sulphate are shown to be beneficial.

Tryptophan is shown to be essential in the early stages of development, and the stimulatory effects of various other adjuvants are discussed.

I should like to express my thanks to Dr B. C. J. G. Knight of these laboratories for suggestions relating to the growth factor requirements of *Streptomyces griseus* and for independent confirmation of the effect of tryptophan on the early growth of the organism; to Dr G. C. Ainsworth for his continual interest and helpful suggestions throughout the progress of the work; and to Miss E. Brookfield for the communication of some of her experimental results recorded in this paper.

My gratitude is also extended to all the members of the staff of these laboratories who took part in the experimental work, especially my assistant, Miss H. Bishop; Miss E. Howard who was responsible for the assays, and Miss G. Puddefoot who performed most of the work of statistical analysis.

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EXPLANATION OF PLATES

PLATE XII

Fig. 1A. *Streptomyces griseus*. 10-day growth. Reading from top to bottom and left to right.

Nitrogen source		p.p.m. trace metals	
A	Ammonium nitrate	0	8
	Ammonium chloride	0	4
	Ammonium sulphate	0	8
	Asparagin	0	32
	Glycine	0	8
			64

PLATE XIII

Fig. 1B

B	Creatin	0	2	32
	Guanidine	0	2	8
	Glycocyanine	0	8	64
	'Casydrol'	0	8	64
	Evans's peptone	0	8	64

Fig. 2. *Streptomyces griseus*. 7-day growth. Reading from left to right.

Control. Ammonium nitrate without growth factors.

Ammonium nitrate + 0.005 % dl-tryptophan.

Ammonium nitrate + 0.002 % alanine + 0.005 % indole-3-butyric acid.



Fig. 1A

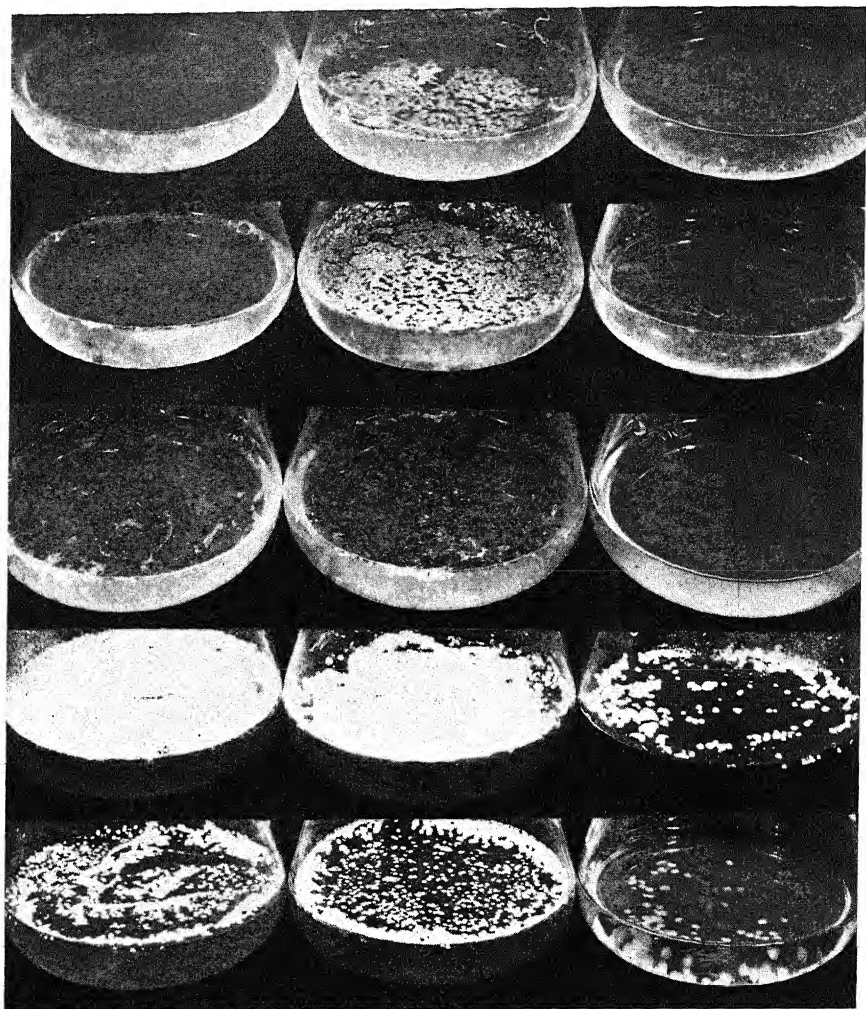


Fig. 1 B



Fig. 2

THE BASIDIOSPORES OF *EXOBASIDIUM VEXANS*

BY C. H. GADD AND C. A. LOOS

Tea Research Institute of Ceylon

(With 1 Text-figure)

Exobasidium vexans was first described by Massee (1898) from material sent by Dr Watt from Assam, where it was causing a serious disease of tea termed 'Blister Blight'. The disease was well described by Watt and Mann (1903) and was later studied by McRae (1910) and Tunstall and Bose (1921) in North India, Du Pasquier (1933) in Indo-China, and by Sawada (1922) in Formosa and Japan.

The disease becomes evident on young expanding leaves as translucent spots which later become conspicuous, circular 'blisters'. The upper surface of the leaf becomes indented to form a circular pit, and the lower surface protrudes to form the so-called blister. A few days later the convex surface of the blister becomes white, with a velvety surface, as the fungus is revealed by the splitting and removal of the cuticle and epidermis.

This disease appeared for the first time in Ceylon in October 1946 and rapidly spread through a large area of tea over 1500 ft. above sea-level. The symptoms leave no doubt that the disease is the same as that described from North India, and in our opinion the causative fungus is undoubtedly *E. vexans* Massee.

In his description of *E. vexans*, Massee described two kinds of spores: (1) small non-septate basidiospores, and (2) large one-septate conidia. Sawada (1922) however put a very different interpretation on his observations. He wrote: 'The present writer believes, however, that the so-called conidia borne on the convex under-surface of the blistered area are really bicellular basidiospores. He has failed to find any spores on the tips of simple conidiophores as described by Massee and McRae. On following out the development of the basidiospores he found that the unicellular spores borne on the basidium may fall from the sterigmata when ripe or may remain attached until the basidia wither and collapse; in either case they ultimately develop a septum.'

The occurrence of the disease in Ceylon gave us an opportunity to study this fungus with special reference to the production of basidiospores and conidia. Our observations lend support to Sawada's view and it is thought that they will be of interest to other students of this group of fungi.

The fungus. The velvety appearance of the convex surface of the blister, when it first becomes white, is due to the presence of dense clusters of vertical sterile hyphae, approximately equal in length, each with a rounded apex. Some of the basidia, if not all, project above this layer and can easily be recognized by the sterigmata (Fig. 1).

In his description, Massee states 'Some of these hyphae run out into

long sterile filaments giving a minutely downy or velvety appearance to the blister when seen under a lens; the great majority of the hyphae, however, remain short and produce a single conidium at the apex'. In his figure of the hymenium, he shows three basidia projecting above a cluster of conidiophores, each conidiophore bearing a thick-walled two-celled spore, but he does not figure any sterile hyphae which give the surface its velvety appearance. Watt and Mann, and Du Pasquier reproduce Massee's figures.

McRae (1910) figures a cluster of vertical hyphae above which one basidium projects slightly. At the apex of some of the vertical hyphae are figured two-celled thin-walled conidia. The conidiophores are of about the same length as the sterile hyphae, not shorter as described by Massee.

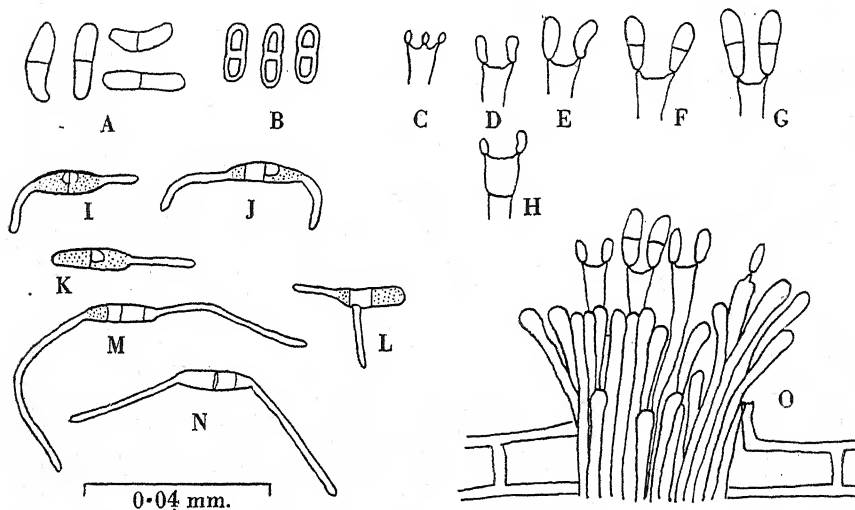


Fig. 1. A, Thin-walled basidiospores. B, Thick-walled basidiospores. C, Basidium with three sterigmata. D-G, Basidia and their basidiospores. H, Basidium with a septum near apex. I-N, Germinating basidiospores. O, Transverse section through a young blister (diagrammatic).

Tunstall and Bose (1921) give a diagrammatic representation of a section through a diseased leaf showing vertical conidiophores and sterile hyphae, the former being distinguished by the presence of solitary one- or two-celled thin-walled spores at their apices. In this respect their interpretation agrees with McRae's.

Conidia. Massee described the conidia as 'hyaline or with a tinge of yellow when seen in the mass, elliptic with somewhat pointed ends, one-septate, slightly constricted at the septum, straight, or sometimes very slightly curved, measuring $14-16 \times 5-6 \mu$ '. Tunstall and Bose describe them as usually single cells, but occasionally uniseptate, measuring $11-21 \times 4.5-6.5 \mu$. Du Pasquier wrote 'Les conidies sont les plus abondantes. L'extrémité renflée du filament grossit, se sépare de la tige par une cloison, et forme une spore amincie aux deux extrémités unicellulaires ou parfois

uniseptées, qui mesure $11-20 \times 4.5-6.5 \mu$. Mann (1906) and McRae describe the spores as two-celled but give no measurements.

There is thus fair agreement regarding the size of the spores, but Tunstall and Bose and Du Pasquier agree that they are usually non-septate. We have found very few non-septate spores except those attached to basidia. Two-celled spores are abundant, free on the surface of the blister, and they are undoubtedly the spores commonly referred to as conidia.

Basidiospores. The basidia are loosely distributed among the sterile hyphae (or conidiophores) and often project somewhat above their level. They are sub-cylindric, usually with two slender spine-like sterigmata (Fig. 1 D-G), though occasionally three have been seen (Fig. 1 C). A septum sometimes occurs near the apex (Fig. 1 H).

Massee described the basidiospores as 'hyaline, continuous, glabrous, ovate, oblong, often slightly inequilateral, $5 \times 3 \mu$ '. Mann writes of them as 'extremely minute oval bodies borne in pairs at the ends of special erections termed *basidia*'. Tunstall and Bose give much larger measurements, $7-13.5 \times 2.3-4.5 \mu$ and describe them as 'sausage-shaped'. Du Pasquier gives Tunstall and Bose's measurements with Massee's figures, and the following description 'Les basidiospores n'apparaissent qu'à certains moments et le plus souvent au début de la saison. L'extrémité du filament se ramifie en 2 à 5 cornes effilées qui portent les spores. Celles-ci sont plus petites que les précédents ($7-13 \times 2.3-4.5 \mu$), hyalines, cylindriques, arrondies aux deux bouts.'

The small spores described by Massee and the larger non-septate basidiospores of Tunstall and Bose are almost invariably attached to sterigmata and leave no doubt that the smaller ones are an earlier stage of the larger ones. Our measurements of the larger non-septate spores gave a range of $6-14 \times 2.8-4.3 \mu$ which, with their shape, indicates that they are the basidiospores of Tunstall and Bose.

At this stage our observations indicated that the basidiospores were non-septate, but no explanation could be offered of the origin of the more numerous septate spores lying on the surface of the blister. There was no evidence that the basidiospore enlarged and became septate after detachment from the sterigmata, as suggested by Sawada. There was the possibility, however, that the spores might enlarge and become septate before detachment, but that hypothesis also carried the proviso that the septate spores must fall at the slightest disturbance.

We were fortunate in having diseased bushes in close proximity to the laboratory and were able to examine freshly gathered material, subjected to a minimum disturbance. In that material we found one-septate spores *in situ* on the basidia (Fig. 1 F, G) and although even small disturbance displaced them, sufficient were seen to afford clear proof of their origin. The two-celled spores attached to sterigmata measured $14-17 \times 3.5-5.6 \mu$. Measurements of similar spores lying on the surface of the blister (Fig. 1 A), and previously regarded as the conidia of Massee, gave a range of $13-27 \times 4.3-6.5 \mu$ and a mean (of 50 spores) of $18.7 \times 5.5 \mu$.

It thus became evident that the larger basidiospores described by Tunstall and Bose are not fully grown, and that the spores lying free on the surface

are in fact mature basidiospores and not conidia as was previously supposed. The unicellular conidia reported by Tunstall and Bose were probably displaced basidiospores though it is somewhat surprising that they were more abundant than the septate form.

Interpretation. The ease with which septate basidiospores are dislodged affords a simple explanation of their abundance on the hymenial surface and their sparsity at the points of production, even in carefully handled material. Yet Massee and others in their figures have shown these spores being produced on conidiophores. Are we to assume that these authors, unable to connect the larger two-celled spores lying on the surface with the non-septate spores visible on sterigmata, concluded that they had some other origin and made an obvious but unjustified reconstruction? Sawada appears to think so, and we incline to that view, not only because of the negative evidence that they had not seen the two-celled spores attached to conidiophores, but also because of the positive evidence connecting the non-septate basidiospores with the one-septate 'conidium'.

One further point needs to be mentioned. Massee's figures show his 'conidia' to be thick-walled. Neither he nor later writers make direct reference to the 'conidia' being thick-walled. The two-celled basidiospores, so abundant on young blisters, are thin-walled, but in older material we have seen numerous free spores with thick walls (Fig. 1 B) similar to those illustrated by Massee. In the same material basidia and hyphae with thickened walls were also seen. It would seem that ageing, or a change in climatic conditions, may induce wall thickening. The size and shape of the thick-walled spores, coupled with the fact that none could be found on a conidiophore, left no doubt in our minds of their identity as basidiospores.

Over-wintering. The spores of *Exobasidium vexans* are reputed to be short-lived, and no very satisfactory explanation has been offered of the manner by which this fungus survives unfavourable seasons and years. The thick-walled basidiospores remind one of resting spores, but whether the thickening of the wall increases the viability of the spore and enables it to survive during unfavourable conditions has not been determined. It is perhaps a hypothesis worth consideration.

Germination. The two-celled basidiospores germinate readily in hanging drops of water, germ tubes emerging in about five hours (Fig. 1 I-N). Usually germ tubes emerge from both ends of the spore (Fig. 1 J), but occasionally an additional germ tube from a side wall has been seen (Fig. 1 L). As germination proceeds the spore begins to clear (Fig. 1 I, K), as though the protoplasm is streaming very slowly into the germ tubes leaving the centre of the spore empty. If only one germ tube is formed, only the half which forms the tube clears (Fig. 1 K). More commonly, both ends produce germ tubes and a circular clear area first becomes evident around the septum (Fig. 1 I). This area enlarges as growth proceeds until the spore is clear and apparently empty (Fig. 1 N).

In such empty spores, not one but two and even three septa are sometimes clearly visible, although before germination only the middle one was apparent. It will be evident that the additional septa are formed, as a rule, during germination, otherwise the flow of protoplasm from the centre into

the germ tubes would be prevented. Support is lent to this view by the fact that spores which produce germ tubes from side walls invariably have an additional septum, which is probably there when germination starts, as the only way by which the protoplasm can move from a middle compartment is by pushing out a germ tube from the side wall. The fact that germinating spores can rapidly make cell-wall material and so form additional septa within the spores possibly supports the view expressed above that under certain conditions the spore is able to thicken its walls by the addition of more material.

No haustoria have been observed either in hanging drops or on leaf surfaces. It is probable therefore, as stated by other authors, that entry into the leaf takes place through the stomata, although such entry has not been seen by us.

SUMMARY

Blister Blight of tea, a leaf disease caused by the fungus *Exobasidium vexans* Massee, occurred for the first time in Ceylon in October 1946 and spread rapidly through a large tea area. Massee and others have stated that *E. vexans* produces two-celled conidia as well as non-septate basidiospores. Sawada has dissented and expressed the view that the two-celled spores are in fact mature basidiospores.

Observations described here support Sawada's opinion. The mature two-celled basidiospores are very easily dislodged from the sterigmata and are usually to be found on the surface of the blister. In carefully collected material we have seen the mature two-celled basidiospores attached to sterigmata, and so have demonstrated the origin of spores lying on the surface: they are mature basidiospores and not conidia. Under certain conditions the cell wall thickens and the spores then closely resemble Massee's figures of 'conidia'. Neither Massee nor later writers make any mention of the 'conidia' having thick walls, which must be interpreted that normally they are thin-walled as seen by us. Massee's drawings of 'conidia' are not in error, though his reconstruction of their origin is.

Germination of the spores is also described. Although the basidiospore is normally one-septate, as many as three septa have been seen in germinated spores. The view is expressed that the extra septa are normally formed during germination.

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ASTERODON, A CLUE TO THE MORPHOLOGY OF FUNGUS FRUIT-BODIES: WITH NOTES ON *ASTEROSTROMA* AND *ASTEROSTROMELLA*

By E. J. H. CORNER, M.A., F.L.S.

(With 9 Text-figures)

Asterodon is a genus of Basidiomycetes with one species, *A. ferruginosus*, which grows on rotten coniferous wood in northern and montane parts of Europe and North America. Its brown resupinate fruit-bodies develop

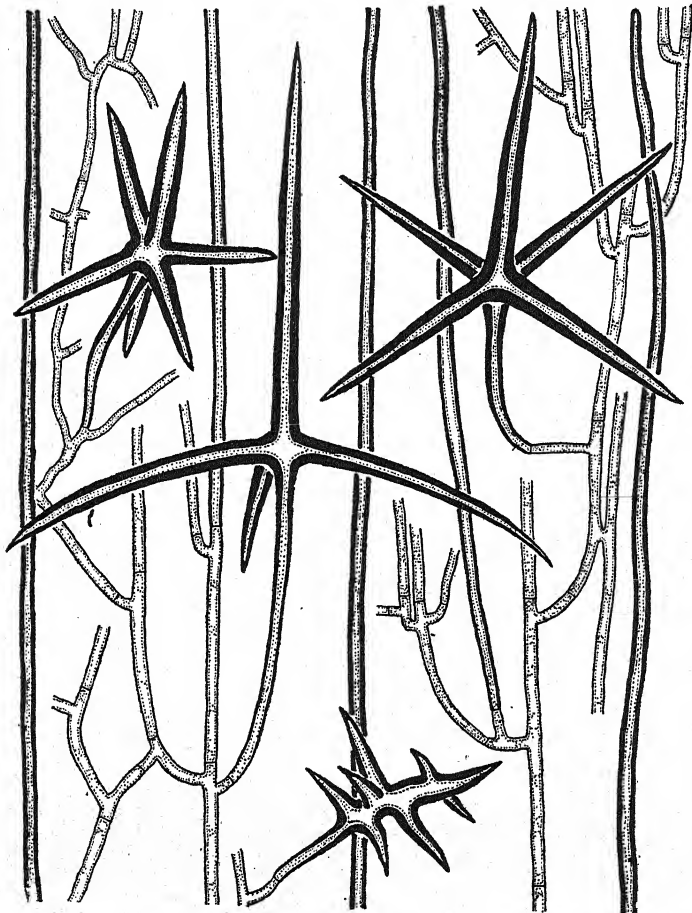


Fig. 1. Skeletal hyphae, generative hyphae and stellate setae from the fruit-body of *Asterodon ferruginosus*, $\times 500$.

Hydnum-like spines which point vertically downward. Mycelial patches on the upper sides of fallen logs are sterile and without spines. Microscopically the tissue of the fruit-body (and, also, that of the mycelium) is peculiar in developing stellate setae with thick brown walls. This feature occurs in *Asterostroma* as well, but it has *Corticium*-like fruit-bodies without spines. Patouillard (1900), therefore, made the group *Asterostromeae*, as a series of the *Hydnaceae*, to cover the two genera. Bourdot and Galzin (1928) treat the group as a subtribe, *Asterostromaceae*, of the *Porohydnameae*. Donk (1933) has pointed out, however, that the group should be placed in the *Hymenochaetoideae* which he regards as a subfamily of the *Aphyllaphoraceae*. Actually the position of the group cannot be decided until the extent of the *Hymenochaetoideae* or, as I prefer to call them, the *Xanthochroic Series* is known. These xanthochroic fungi are distinguishable not so much by the *Hymenochaete* setae, which are absent from many of them, as by the characters of their hyphae. The absence of clamp connexions, the lack of inflation of the cells of the fruit-body, and the ochraceous or brown colour of the hyphal walls, which darkens to ferruginous or date brown with alkali, distinguish these fungi. Their fruit-bodies may be *Clavarioid* (as *Lachnocladium*), *Hydnoid*, *Stereoid*, *Corticoid* or *Polyporoid*; they have a prevailing yellow-brown colour and fibrous, coriaceous or ligneous texture; and they are built up entirely by apical growth (thus the *Agaric* form with its typical button stage is absent). Setae, dichophyses, skeletal hyphae, gloecystidia and so on distinguish various genera, or subgenera, but, except as products of this kind of hypha, they are not unique, for similar organs occur in other series of *Basidiomycetes*.

In this paper I wish to explain how this little-known fungus, which may be amenable to laboratory culture and experiment, has two features which should greatly assist in investigating the form factors, or evocators, of the fruit-body: they are the plastic growth of the setae and the direction of the skeletal hyphae.

DESCRIPTION OF *ASTERODON FERRUGINOSUS*

A. ferruginosus Pat., *Bull. Soc. mycol. Fr.* x, 1894, 129.

Synonym: *Hydnum ferruginosum* Fr. fide Lundell, *Sver. Svamp. fasc.* VII-VIII, 1936, 23.

Synonymia alia vide Rogers et Jackson, *Farl.* 1, 1943, 271.

Fruit-body resupinate, widely effused, forming a floccoso-felted ferruginous-ochraceous or tawny subiculum of very variable thickness, 0.2-8 mm. thick; margin bright tawny ochraceous, floccose, often tumid; spines 1-1.5 mm. long, 0.2-0.3 mm. wide at the base, developed centrifugally, crowded in the centre, subulate, simple, subpruinose fawn-brown.

On very rotten coniferous wood: Sweden, Finland, Siberia (on *Abies sibiricae* and *Pinus silvestris*, fide Pilat), France, U.S.A. (on *Pinus* and *Abies*).*

Spores $5-6 \times 4-4.5 \mu$, or $6-8 \times 4-5 \mu$ (Corner, *Rel. Farlow.* 302), white, smooth, ellipsoid, aguttate.

Basidia $18-25 \times 5-8 \mu$, or $14-20 \times 6-7 \mu$ (Corner, *Rel. Farlow.* 302): sterigmata 4, $4-5 \mu$ long.

Cystidia $16-25 \times 3-5 \mu$, subventricose with a narrow cylindric appendage 1.5μ wide,

* According to Pilat (1935), the specimen recorded on *Populus* by Bourdot and Galzin is *Hymenochaete cinnamomeum*.

thin-walled, colourless, vacuolate, only in the incipient hymenium at the tips of the spines and at the margin of the resupinate part, soon collapsing.

Hymenial setae $25-45 \times 5-10 \mu$, fusiform-subventricose, acute, straight or curved at the base, with smooth thick brown walls, *mostly simple on the spines, usually substellate with 1-4 short branches in the intervals between the spines.*

Extrahymenial setae only in the tissue of the spines, $60-170 \times 6-7 \mu$, straight, longitudinal, simple or, rarely, once bifurcate (never stellate), sometimes with a short lateral branch transformed into a hymenial seta, aseptate, acute, with smooth brown walls to 2.5μ thick, with a longer or shorter stalk tapered to the generative hypha.

Stellate setae only in tissue of the resupinate part of the fruit-body, with 4-6 acute arms to 90μ long $\times 5-7 \mu$ wide at the base, rigid with smooth brown walls $1-2 \mu$ thick, rarely once bifurcate, often somewhat curved, aseptate, the central body scarcely enlarged, the stalk to 100μ long and tapered to the generative hypha: *largest in the basal tissue next the substratum, smaller towards the subhymenium, and with all gradations to the substellate hymenial setae between the spines.*

Hyphae dimitic:* generative hyphae $1.5-3 \mu$ wide, septate without clamps, with thin and colourless, or slightly thickened and pale ochraceous, smooth walls: skeletal hyphae $2.5-3.5 \mu$ wide, unbranched, or rarely bifurcate once, aseptate, unlimited, with smooth brownish ochraceous walls, $0.5-1 \mu$ thick, the lumen distinct.

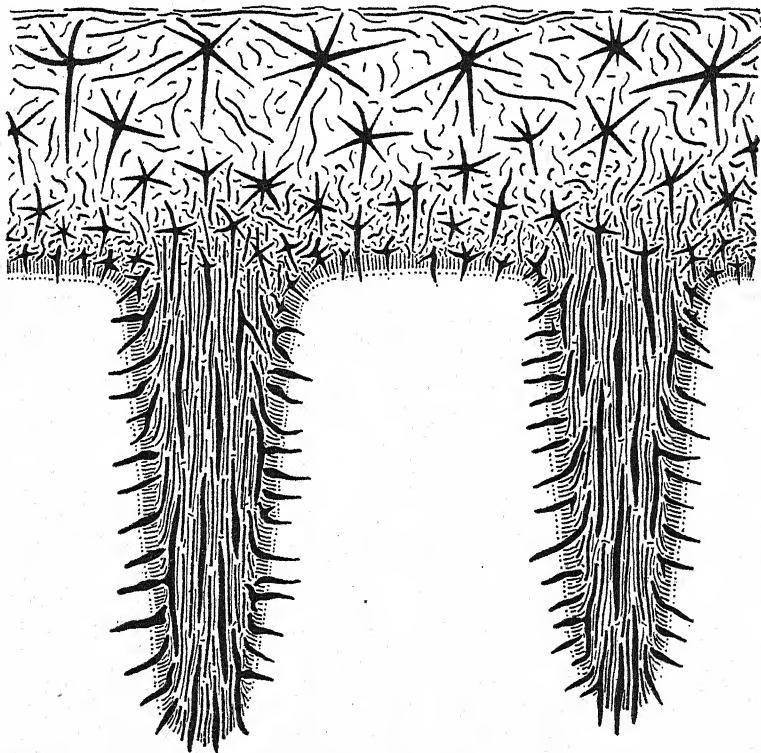


Fig. 2. A diagram of the structure of the fruit-body of *Asterodon ferruginosus*, showing the resupinate base and two down-pointing spines. The skeletal hyphae are shown by thicker lines than the generative hyphae.

* Meaning with two kinds of hyphae, in contrast to monomitic and trimitic (Corner, 1932a).

Structure of the fruit-body. The general construction is shown in Fig. 2, and details of the hymenium in Figs. 3 and 4. The main features are the direction of the hyphae and the size, shape and direction of the setae. In the resupinate flesh, the hyphae are loosely interwoven in all outward directions from the substratum, but they have a horizontal centrifugal tendency in the basal layer next the wood. The skeletal hyphae end obliquely in the hymenium or subhymenium or against the substratum

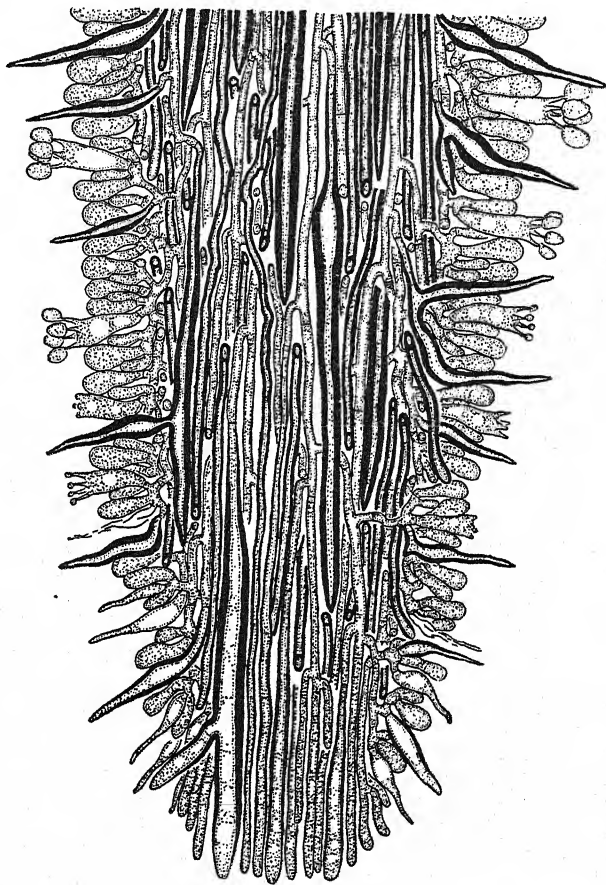


Fig. 3. A longitudinal section of the tip of a spine of *Asterodon ferruginosus*, $\times 500$.

and have simple cylindric tips. The tissue is denser towards the subhymenium because of the more frequent branching of the generative hyphae and the greater number of small stellate setae. The subhymenium itself, is poorly defined, $5-10\mu$ thick, and the hymenium is a continuous, unthickened palisade $16-20\mu$ deep. In the spines the hyphae are strictly longitudinal, entwined but not interwoven: the skeletal hyphae are often kinked or irregularly flexed unlike those of the resupinate flesh. The

density of the tissue of the spines is caused by the abundance of compactly longitudinal skeletal hyphae and the numerous extrahymenial setae among them. The tips of the spines are sterile and are composed of the down-growing ends of the three tissue-elements.

Development of the fruit-body. Although I have not seen young specimens, it is clear that the resupinate part must develop as a superficial centrifugal outgrowth from the mycelium in the wood. It varies greatly in thickness

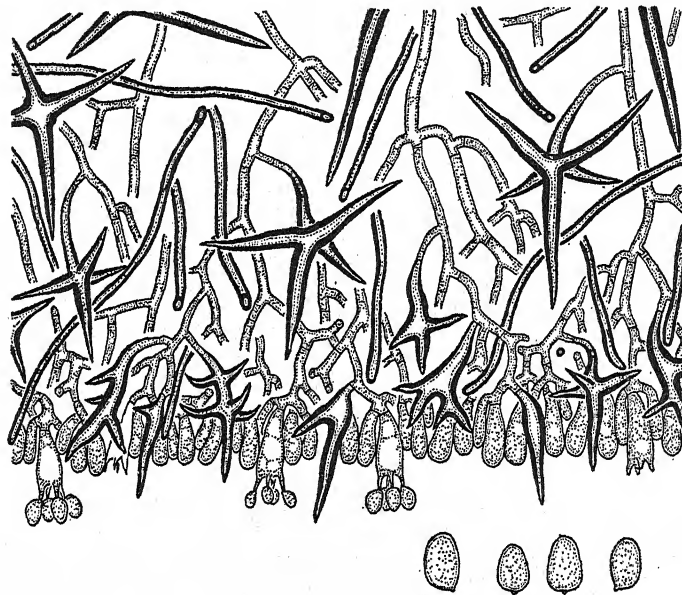


Fig. 4. A section of the hymenium between two spine bases of *Asterodon ferruginosus*, $\times 500$; spores, $\times 1000$.

and is composed of hyphae which have at first grown outward in all directions, so as to be loosely interwoven, and are compacted by the arms of the stellate setae. At a certain stage of development the uniform outgrowth slows down: the stellate setae become smaller, with shorter branches and more evident axis at right angles to the future hymenium, and the generative hyphae branch more freely. The downgrowth then stops: the end-cells of the generative hyphae become hymenial setae or basidia and, by sympodial intercalation of new basidia, the single-layered hymenium is constructed. In certain parts, however, or, indeed, over the whole central region of the incipient hymenium, there develops a 'field' corresponding to the pore-field of polypores (Corner, 1932*b*), in which the spines arise as localized areas of downgrowth 0.2–0.3 mm. in diameter. All the hyphal tips in such an area become positively geotropic and, in the renewed excrescence, aline themselves to build the spine. Thus the formation of the spine is unidirectional in contrast with the multidirectional development of the resupinate flesh. Subsequently the hymenial factor develops on the

spine and makes the hyphal ends on the sides of the down-growing fascicle of hyphae turn out at right angles, as if diageotropic, to construct the hymenium. The spines are the positives of the tubes of polypores.

The direction of the hyphae. As there is no inflation of the skeletal hyphae, which soon become more or less rigid with thickened walls, they suffer no displacement and their direction in the mature tissue shows the original direction of their apices, which in turn implies the direction of the force controlling their growth. In the basal layer of the resupinate flesh there

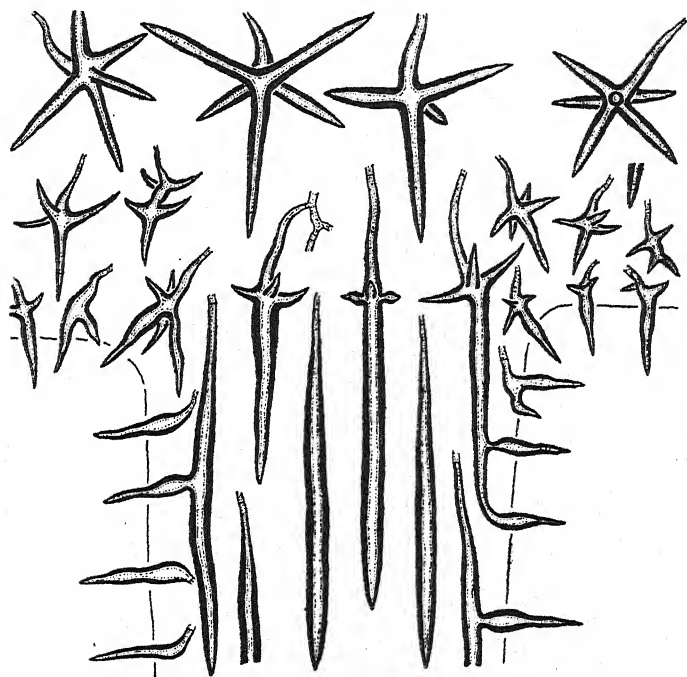


Fig. 5. A longitudinal section of the base of a spine of *Asterodon ferruginosus* to show the position and shape of the setae, $\times 500$.

appears to be a centrifugal force causing alinement of the hyphae against the substratum: it may be thigmotropic or diageotropic. In the rest of the flesh there appears to be no controlling factor other than an inherent divergence, as a general excrescence, which dies away until resuscitated by positive geotropism in the spine areas or terminated by the hymenial factor in the network surrounding the areas. Eventually a similar diversion of the hyphal tips on the sides of the spines, as occurs in the basal layer of the flesh, leads to the acropetal extension of the hymenium down the spines, the tips of which, however, are always sterile. This point and the fact that the hymenium never develops on upturned resupinate surfaces show, nevertheless, that the hymenial factor is in some manner geotropic as well as intrinsic.

The shape of the setae. It is, at first, puzzling that a fruit-body, which is so apparently simple, should have such a variety of hyphal endings. If it be assumed, however, that the setae are hyphal ends of limited growth not entirely deprived of the faculty of branching, then it can be seen that their shapes express the form-factors of the fruit-body. In the loose tissue of the resupinate flesh, the stellate form with equal branches indicates the multi-directional outgrowth of the hyphae where there are no evident form-factors: that is, the stellate form is the uninhibited. As the outgrowth dies away, so the stellate setae become smaller. In the hymenium, where the hyphal ends no longer branch, the setae become simple and aligned with the basidia. The parts of the setae which lie in the subhymenium become shortly branched to form the substellate setae of the hymenium between the spines. In the spines branching is suppressed and the setae are transformed into the elongate longitudinal extrahymenial setae, expressing the unidirectional parallel (not expanding) downgrowth, but where the peripheral extrahymenial setae come within the influence of the hymenial factor near the tip of the spine, they produce an out-turned branch which becomes a simple hymenial seta, as does any hyphal tip which becomes modified into a seta in this hymenium. In proof of this relation between the shape of the seta and the form-factors of the fruit-body, and as an indication of what takes place in the spine area on inception of a spine, one can analyse the shapes of the setae at the base of the spine, as shown in Fig. 5. Just before the spines develop, outgrowth in the spine area is stimulated and the tips of any hyphae in the area are affected; thus, the setae at the base of the spine have often reduced arms at the level of the hymenium between the spines and an elongate ray entering the base of the spine as one of the first-formed extrahymenial setae: such are, in fact, diminutive stellate setae of the resupinate flesh caught in the act of development and converted into setae of the tissue of the spine. The slightly oblique ray shown in Fig. 5, as entering the base of the spine on its right, has become caught in the hymenium and terminates as a hymenial seta as well as providing a branch. The corresponding seta on the left of the spine base, however, has just escaped the hymenium and been deflected into the tissue of the spine where it ends blindly. The two examples show that the influence of the hymenial factor, whatever it may be, is sharply delimited and that the narrow subhymenium, so difficult to examine and to define microscopically as often to be overlooked, expresses in its very nondescript appearance the neutral zone between the medullary tissue of the spine and its hymenial envelope.

Relation between setae and skeletal hyphae. The two elements are always distinct in this fungus. Both arise from generative hyphae, as modified laterals, but always independently, the stalk of one never connecting directly with the stalk of the other. The setae have limited growth and become embedded in the tissue: the skeletal hyphae have unlimited growth and terminate at the surface of the fruit-body. Both are thick-walled and aseptate, but the skeletal hyphae are only half as wide as the extrahymenial setae or as the arms of the stellate setae. Thus this fungus corroborates the impression gathered from the xanthochroic polypores (Corner, 1932c) that

there are extrahymenial setae, as well as skeletal hyphae, in the construction of xanthochroic fruit-bodies.

EXPERIMENTAL USE

If *Asterodon ferruginosus* can be induced to fructify in artificial culture, the shape of the setae and the direction of the skeletal hyphae under different experimental conditions should reveal how the hyphae have reacted. Thus, rotation on a klinostat, the effect of various radiations, or the action of gaseous or volatile chemical compounds could be studied in an attempt to find out what are the factors influencing hyphal growth and the development of hyphal tissues—matters which at present merely excite wonder. It should be possible, also, to find out by differential response what is the difference between setae and skeletal hyphae and, thus, what is the meaning of one of the distinguishing features of this series of Basidiomycetes.

ASTEROSTROMA MASS.

This genus has the stellate setae of *Asterodon*, but its fruit-bodies are Corticioid without spines, the hyphae are monomitic (without skeletal), and there are no extrahymenial or hymenial setae (unless, perhaps, in *A. degenerans* Bres.); in their place most species have thin-walled colourless cystidia, containing large oil globules, which are homologous with the gloecystidia of *Lachnocladium*. There are some twenty species, mostly lignicolous and, probably, in the main tropical. I have studied several species in Malaya and find their construction essentially as in *Asterodon*, but simpler. The fruit-bodies have a thin basal layer of horizontal hyphae, spreading over the substratum, from which a loose cortex develops on the lower side as a vague multidirectional excrescence of hyphae with retarding growth: finally, this is covered by the even, single-layered hymenium. The largest stellate setae occur in the basal and initial region of the cortex and they decrease in size towards the hymenium. *A. degenerans* seems to have substellate setae transitional to typical *Hymenochaete*-setae, that is, with a few short basal branches. In a few species, as *A. ochroleucum* Bres., the branches of the stellate setae may be once dichotomous, or even 2–3 times (*A. laxum* Bres.): in *A. muscicolum* (B. & C.) Mass. there appear to be irregular shapes suggesting transition to the dichophyses of *Asterostromella*. Some species, as that figured in Fig. 6, have small basidia; others have strongly projecting basidia as in *Asterostromella*, but always in a continuous layer.

ASTEROSTROMELLA V. HOEHN. & LITSCH.

This genus is composite and consists of species related with *Aleurodiscus*, of true xanthochroic fungi, and, probably, of other Thelephoraceous derivatives. Its character is the presence of dichophyses, as thick-walled dichotomizing hyphae of limited growth, forming the mass of the tissue in the resupinate Corticioid fruit-body. I wish to indicate merely the xanthochroic species, several of which I have studied in Malaya. They resemble *Asterostroma* in most points, particularly the monomitic construction without

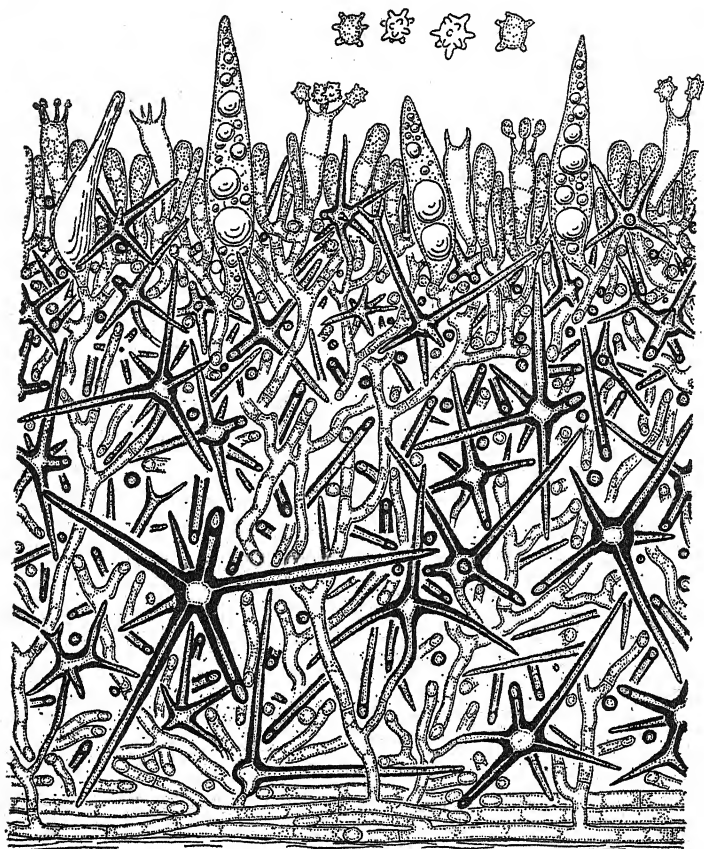


Fig. 6. A section of the resupinate fruit-body of *Asterostroma* sp. (Malaya),
 $\times 500$; spores, $\times 1000$.

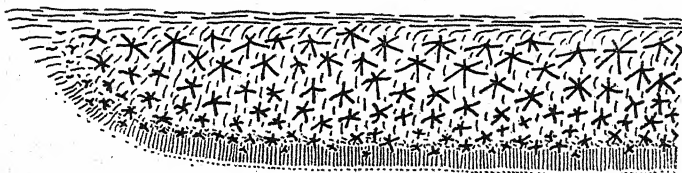


Fig. 7. A diagram of the structure of the fruit-body of *Asterostroma* sp. (Malaya),
 as shown by a radial section of the margin.

clamp connexions, as shown in Figs. 8 and 9. The dichophyses are lateral branches of the generative hyphae, which are usually extremely tenuous and difficult to see: the dichophyses have limited growth, though the thinness of the fruit-body may obscure this fact, and in place of the stiff radiating arms of the stellate setae they become progressively dichotomous

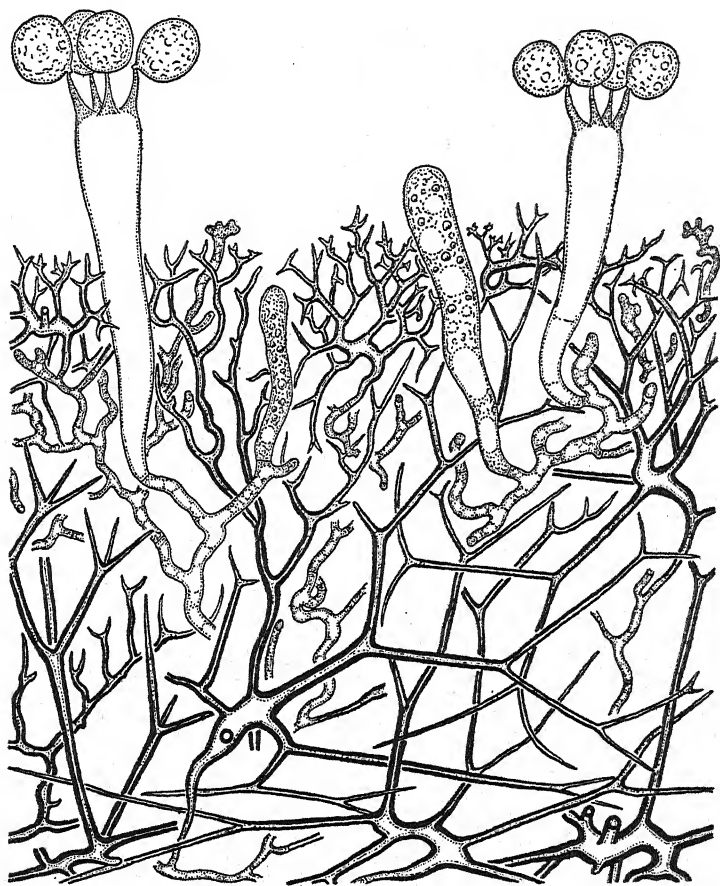


Fig. 8. A section of the resupinate fruit-body of a xanthochroic species of *Asterostromella* from Malaya, much simplified, $\times 1000$.

with longer and longer, tapering internodes ending in acute colourless tips 0.5μ wide or less. The dichophyses also become smaller toward the hymenium where they are usually coralloid clumps so dense and closely set that the basidia project between them at wide intervals and never build a continuous layer. In one species that I have seen the hymenial dichophyses are shaped like the digitate cystidia on the gill-edge of *Androsaceus* (Marasmieae) and may even be simple, but such are merely rudimentary states, and true setae seem not to occur. Gloeocystidia may or may not be

present. The hymenium may remain as a vague layer or it may thicken, either continuously by the outgrowth of new hyphae to form dichophyses and basidia or intermittently in seasonal layers.

The xanthochroic species are related to *Lachnocladium* and I have found in Malaya a pleuropodal 'Stereum' with the same construction. The

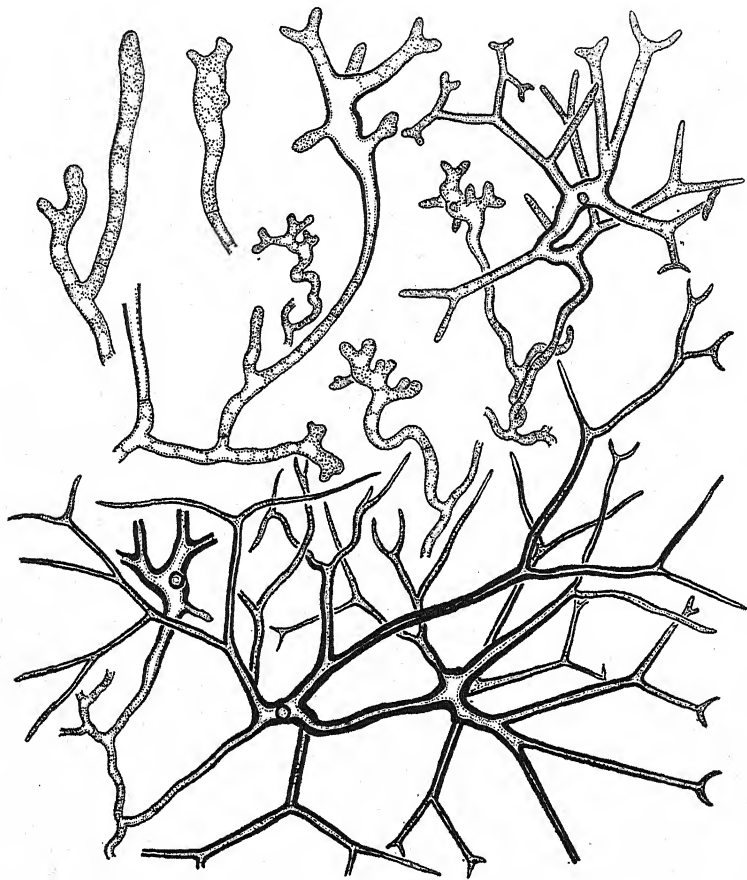


Fig. 9. Stages in the development of the dichophyses of a xanthochroic species of *Asterostromella* from Malaya, $\times 1000$.

critical genus seems to be *Hymenochaete*, the tropical species of which are certainly of diverse affinity, some having the dichophyses of *Asterostromella*, others the skeletal hyphae of *Asterodon*. The genus may provide instances of transitions between dichophyses and stellate setae, which appear to be regularized dichophyses with simple arms. I have not seen any xanthochroic Polyporoid or Hydroid fungi with dichophyses.

SUMMARY

The structure of *Asterodon ferruginosus* is described. It is dimitic with stellate setae, extrahymenial setae and hymenial setae, as well as skeletal hyphae. The shape of the setae and the direction of the skeletal hyphae express the action of the form-factors of the fruit-body. The fungus seems to be most suitable for experimental investigation of these obscure processes.

The structure of *Asterodon* is further illustrated by reference to *Asterostroma* and the xanthochroic species of *Asterostromella*. *Hymenochaete* appears to be the critical genus for the elucidation of the structure and affinity of these fungi.

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A TECHNIQUE FOR RAPID DEMONSTRATION OF THE PRODUCTION OF ANTIFUNGAL SUBSTANCES BY FUNGI OR OTHER MICROORGANISMS

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INTRODUCTION

Most techniques previously described for the determination of the production of antifungal substances by fungi or other organisms have involved growth of the fungi on liquid media, serial dilutions of the culture filtrate being then assayed.

Weindling (1934) produced culture filtrates of *Trichoderma lignorum* and observed microscopically the effect of serial dilutions on young hyphae of *Rhizoctonia solani*. Brian and Hemming (1945) again used serial dilutions of culture filtrates. These solutions were tested to determine the highest dilution at which they prevented germination of the spores of the test organisms. Irving, Fontaine and Doolittle (1945), using solutions of an antifungal substance produced by tomatoes, employed an assay technique analogous to the cylinder plate technique used in penicillin assay, the activity being determined by the diameter of a zone of inhibition.

These techniques are more in the nature of quantitative assays rather than preliminary sorting tests.

The use of direct inhibition of the growth of one fungus by another in a streak test was shown by Brian, Curtis and Hemming (1946) to be possible, provided that the test fungus is a yeast-like, rapidly growing form. They used *Endomycopsis albicans*. This type of test, widely used for demonstration of antibacterial substances, cannot be satisfactorily used with mycelial fungi as the test organism.

Where a large number of fungi are to be tested for antifungal activity, the above tests (except the streak test which has other disadvantages noted later) are liable to become very cumbersome, and it was considered desirable to develop a rapid technique using as little time, labour and material as possible. After a number of experiments on various lines, the following technique was developed.

TECHNIQUE

A 7 mm. diameter glass rod is bent to form a flat rectangular cell of 1 by 2 in. internal dimensions. This cell is sterilized by flaming and immediately placed in a sterile Petri dish. A small quantity of molten, sterile Czapek-Dox agar is poured into the cell, the quantity being only sufficient to flow round the edge of the cell, sealing it to the base of the dish on cooling. Other agar media can of course be used for fungi which do not grow satisfactorily on Czapek-Dox. When the agar has set, the cell is completely

filled with agar and again left to cool. Some agar usually flows over the edge of the cell or through the gap left between the two ends of the rod and this is removed with a sterile scalpel or spatula. The upper agar surface is then inoculated with a streak of the fungus under test. After two to three days incubation at 25° C. (or when good growth has taken place) the cell is gently prised off the bottom of the dish with a scalpel, picked up with forceps, turned over and transferred to a second sterile Petri dish, sterile precautions being observed throughout. The newly exposed surface is then inoculated with a spore suspension of the test fungus (*Botrytis Allii* Munn being frequently used in these laboratories). After a further sixteen to eighteen hours incubation the upper surface is examined with the low power of the microscope to determine the degree of germination.

RESULTS

In the following table, germination is classified on a 0-4 basis as follows:

0	No germination	2	20-50 % germination
(1)	Up to 5 % germination	3	50-80 % germination
I	5-20 % germination	4	80-100 % germination

It should be noted that little significance is attached to the difference between class 3 germination and that in class 4.

It is often possible to note a gradation of germination between the spores of *Botrytis* directly over the streak of the fungus under test (column (i)) and those away from the streak (column (ii)).

Germination of *Botrytis Allii* in glass cell activity trial on Czapek-Dox

Fungus tested	(i)	(ii)	Antibiotic produced
<i>Absidia glauca</i> Hagem	4	4	None
<i>Botrytis Allii</i> Munn	4	4	None
<i>Fusarium caeruleum</i> (Lib.) Sacc.	4	4	None
<i>Fusarium graminearum</i> Schwabe	4	4	None
<i>Metarrhizium glutinosum</i> S. Pope	—	(1)	Glutinosin
<i>Penicillium Gladioli</i> McCull. & Thom	—	(1)	Gladiolic acid
<i>Penicillium Janczewskii</i> Zal.	—	2	'Curling-factor'
<i>Stachybotrys atra</i> Corda	1	1	Not yet isolated
<i>Stemphylium</i> sp.	4	4	None
<i>Stereum purpureum</i> Pers.	3	4	None
<i>Thamnidium elegans</i> Link	3	3	None
<i>Trichoderma viride</i> Pers. ex Fries	—	—	Viridin
<i>Trichoderma viride</i> Pers. ex Fries	—	1	Gliotoxin
Uninoculated controls (2)	4	4	—

It will be seen that germination of the spores of *Botrytis* after sixteen hours incubation is always suppressed or absent where an antibiotic is known to be produced. The results are consistently repeatable.

DISCUSSION

This technique has several advantages over those previously reported. It is quick, taking only about four days to complete. The glass cells are simple to make and easy to handle though it should be noted that care must be

taken when removing the agar-filled cell to insert the scalpel under the agar as well as the glass in order that both are transferred together. This process is quite easy after a little practice and is facilitated by having cells no wider than 1 in. Finally the technique is very useful with quickly growing fungi which, in the streak test, are very liable to overgrow the test organism before any result can be obtained.

Although this technique has been used only for demonstrating the production by fungi of antifungal substances, it could probably equally well be used to investigate the production by bacteria and actinomycetes of substances antagonistic to fungi, bacteria or actinomycetes.

SUMMARY

A new technique is described for rapidly determining whether a mould or other micro-organism produces antifungal metabolic products. This requires the use of a small rectangular glass cell filled with agar of which one side is inoculated with the fungus under investigation and the other side is later inoculated with a standard test fungus.

The author wishes to thank Dr P. W. Brian for much valuable help and advice.

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A NEW SPECIES OF *PYRENOPHORA* FROM ITALIAN RYEGRASS

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(With Plate XIV and 7 Text-figures)

Diedicke (1903) mentioned a *Helminthosporium* leaf-spot of perennial ryegrass in Germany. He remarked that lesions were produced resembling those caused by *H. teres* on barley and *H. Bromi* on *Bromus inermis* (i.e. they were net-lesions), but he found no associated ascigerous stage and published no further details. Drechsler (1923) described from the United States a *Helminthosporium* leaf-spot of *Lolium multiflorum* Lam. (*L. italicum* A.Br.) and of *L. perenne* L. under the name of *Helminthosporium siccans* n.sp., and this organism was said to produce only spot lesions on these hosts. In the same paper he described a closely related species, *H. dictyoides*, which formed net-lesions on *Festuca elatior* L. (*F. pratensis* Huds.).

It has recently been pointed out that the study of graminicolous *Helminthosporia* has been neglected in Britain (Dennis & Wakefield, 1946), and the first British record of ryegrass leaf-spot was published by Sampson and Western (1940), although the disease had been familiar to Miss Sampson at Aberystwyth since 1922. Material was collected in Scotland by Dennis in 1932, but the record was not published until ten years later (Dennis & Foister, 1942). There is little doubt that the disease has been overlooked, as it is relatively common in Scotland and may be found on wild populations of *Lolium perenne* remote from cultivation.

The types of lesions reported on the two species of ryegrass are summarized in the following table:

Table 1

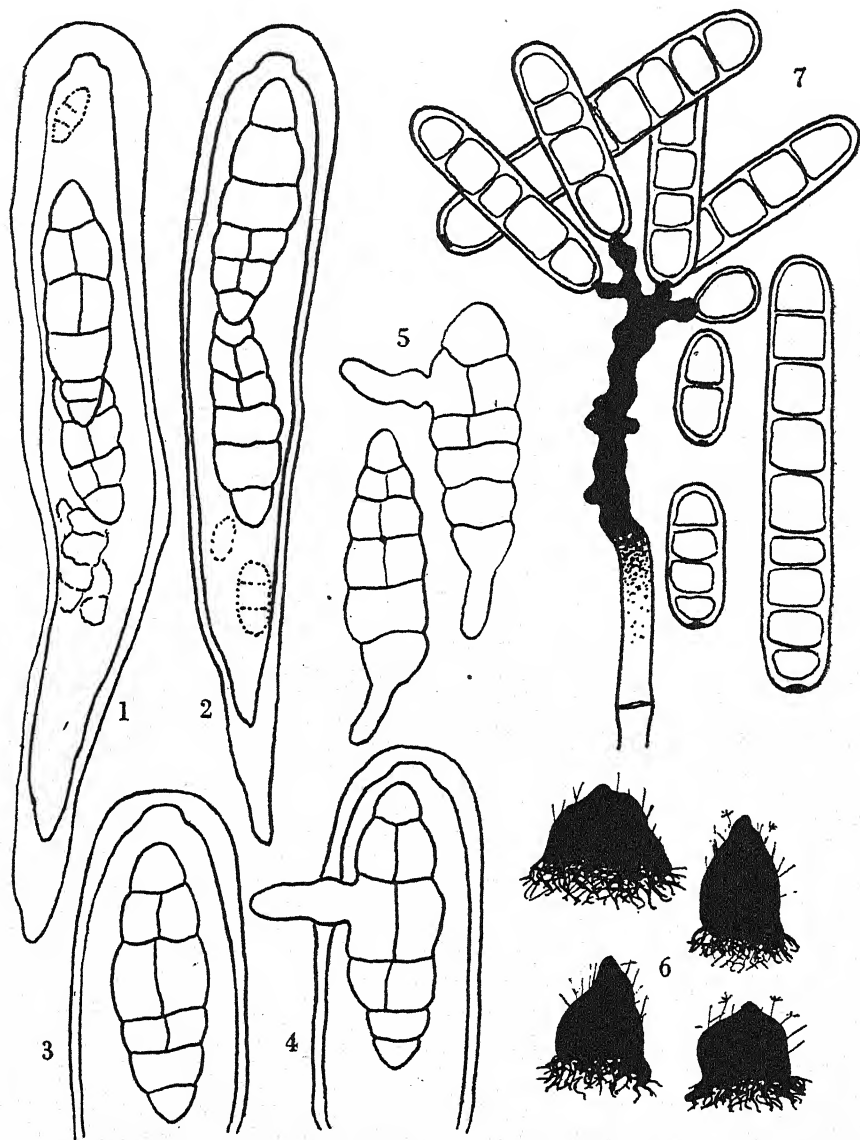
Author	Country	Lesion type
Diedicke, 1903	Germany	Apparently net lesions
Drechsler, 1923	U.S.A.	Spot lesions only
Sampson and Western, 1940	Wales	Spot lesions only
Dennis and Foister, 1942	Scotland	Net and spot lesions

There can be no doubt that in Scotland both spot and net lesions are present on both perennial and Italian ryegrass, but in general net lesions are most clearly developed on Italian ryegrass.

Sampson and Western (1940) concluded that their material corresponded to *Helminthosporium siccans* Drechsl., but the nature of the lesion types and the specific identity of the British organism or organisms will be described in a later paper. It is proposed to describe here only the ascigerous stage of a *Helminthosporium* which causes net lesions on Italian ryegrass.

During the last two years large numbers of monospore cultures have been

made from a range of lesion types on cultivated Italian and perennial ryegrass. Leaves bearing particular types of lesions were taken from experimental plots and kept in a damp chamber for three days; single spores



Text-figs. 1-7. 1 and 2, two asci with normal and abortive spores; asci with six to eight spores are considerably wider. $\times 600$. 3, normal spore and truncate apex of three-spored ascus. $\times 600$. 4, germination of spore directly through the wall of ascus after twenty-four hours in water. $\times 600$. 5, spore germination after eighteen hours in water at 60° F. $\times 600$. 6, Perithecia, $\times 20$. Conidiophores and spores of *Helminthosporium* are visible on those to the right. 7, Conidiophores and spores from the top of a perithecium. $\times 600$.

were then picked off under a binocular microscope with a dry needle and transferred to oatmeal agar.

Cultural characters are similar to those described by Sampson and Western (1940): light grey aerial mycelium, olive-green plectenchyma, and spore production abundant after three weeks. Development of sclerotia is variable in different isolates: sometimes very few are present, but occasionally they are numerous and large. Generally speaking, when sclerotia are well represented development of aerial mycelium and *Helminthosporium* spores is correspondingly sparse. The sclerotia are filled with an oily filamentous tissue of vertical orientation but indefinite structure (Pl. XIV, fig. 4), and externally they bear flexuous tapering setae. They are often well developed in cultures made on sterilized ryegrass straw, but until recently only traces of asci have been observed. However, one culture made on oatmeal agar in September 1946 produced in February 1947 a quantity of ripe asci and spores, which proved that the sclerotia were immature perithecia and confirmed the general prediction of Drechsler. Commenting on the appearance of subspherical sclerotia in cultured material of several species he remarked: 'The writer is inclined to believe that in whatever species such sclerotia or abundant anastomoses (resulting in the production of complexes of lobulate segments) are found to occur, perithecia may be sought with considerable prospects of success.' The anastomoses referred to are abundant in the plectenchymatic layer of the ryegrass *Helminthosporium*. These cultures made in September 1946 were kept outdoors, and the very cold winter of 1946-7 may have facilitated the production of asci and spores, as Drechsler found with *Pyrenophora teres* that 'abundant moisture and a relatively high temperature appear to favour the conidial stage, and it is not illogical to expect that a long protracted period of cold, dry weather in Spring might result in the production of more nearly normal spores'. Temperatures were very low at Auchincruive during January and February 1947, and more than once reached 0° F.—a very rare condition in the west of Scotland.

***Pyrenophora Lolii* Dovaston sp. nov.**

Perithecia inaequaliter conformata, 300-1000 μ diametro (av. 710 \times 550 μ), maturitate rostello conico brevi praedita, 1-50 setulis flexuosis multiseptatis attenuatis ad 200 μ longis basi 8-11 μ crassis ornata. Asci octospori, numerosi, 172-185-230 \times 27-34-41 μ , late cylindrici, apice truncati, annulato-incrassati, basi pedicillati, pedicello quam in *P. Avenae* et *P. tereti* longiore. Sporae pallide brunneae, 49-58-67 \times 16-18-22 μ , plerumque transverse 5-septatae, longitudinaliter 0-4-(saepe 2-) septatae. Sporae saepe abortivae, sed plurimi asci 2-6 sporas perfectas exhibent. Germinatio celeriter evenit, tubulis germinationis lateralibus 1-5 (plerumque 2).

Hab. in substrato solido artificiali ('oatmeal agar' appellato) culta: culturae e spora singula *Helminthosporii* sp. maculas reticulatas in *Lolio italico* Huds. excitantis oriundae, Auchincruive, Ayrshire, Scotia.

Pyrenophora Lolii Dovaston n.sp.

Perithecia irregular in shape, $300-1000\mu$ in diameter (average $710 \times 550\mu$), with a short conical beak when mature, externally $1-50$ flexuous, tapering, multicellular setae may be present $8-11\mu$ in diameter at the base, and up to 200μ long. Asci 8-spored, numerous, $172-185-230 \times 27-34-41\mu$ broadly cylindrical when mature, apex truncate and with a thickened apical ring, stipe longer than in *P. Avenae* and *P. teres*. Spores pale brown, $49-58-67 \times 16-18-22\mu$ nearly always with 5 transverse septa when mature and with 0 to 4 (mostly 2) longitudinal septa. Spores frequently abortive, and most asci show 2 to 6 normal spores. Germination prompt, with 1 to 5 (mostly 2) lateral or polar germ tubes.

Habitat. In a single spore culture on oatmeal agar from a *Helminthosporium* which produced net lesions on *Lolium italicum* Huds., Auchincruive, Ayrshire, Scotland.

Conidiophores and spores of a *Helminthosporium* often develop on the upper surface of the perithecia, and these correspond in morphological characters with *H. siccans* Drechsl., but they have not yet been compared with American material.

A comparison of the above measurements with the corresponding ones for the related *Pyrenophora teres* Drechsl., *P. Bromi* Drechsl., and *P. Avenae* Ito and Kuribay, shows that the present organism more closely resembles *P. Avenae* than do the other two.

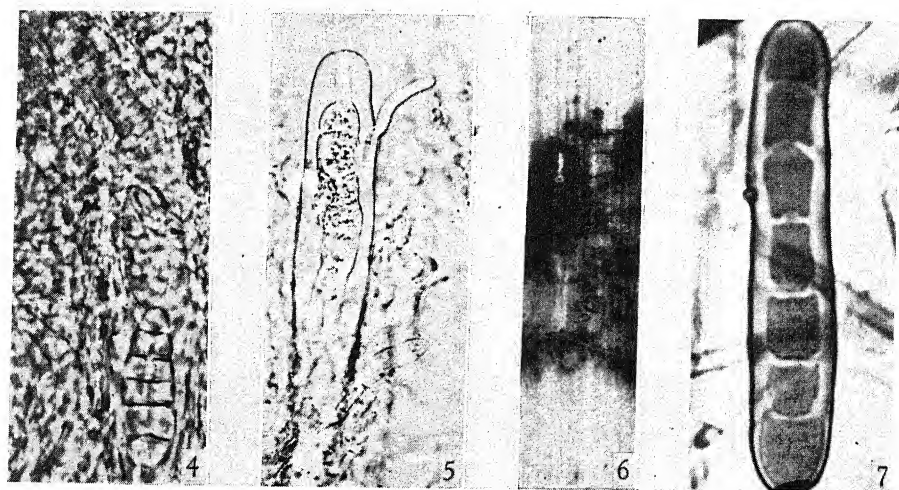
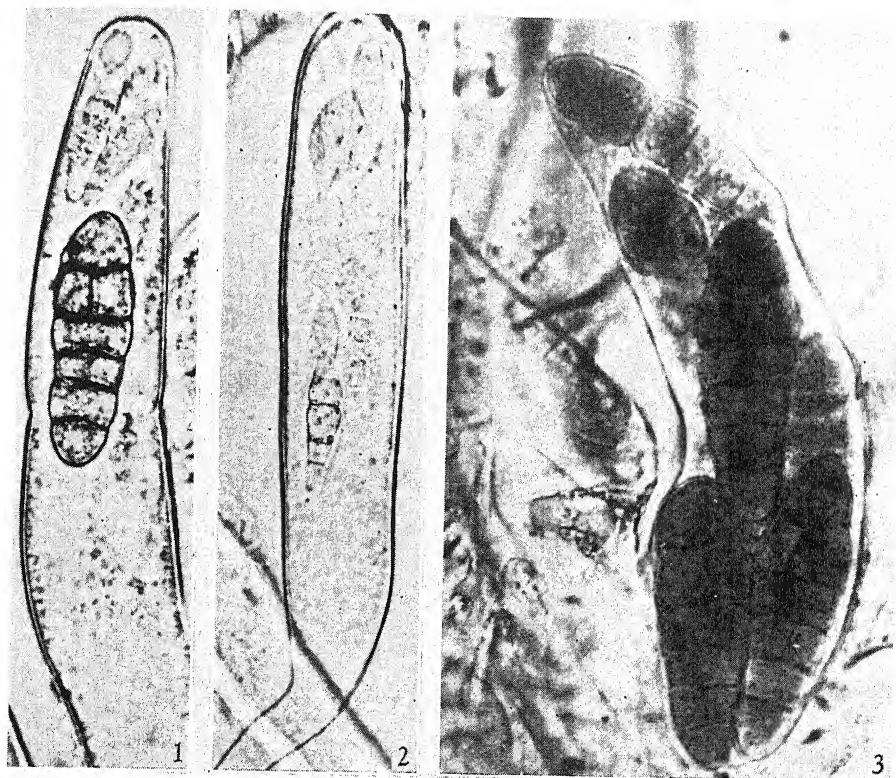
Approximate modal measurements in *Pyrenophora* species are given in Table 2. The data for *P. teres* and for *P. Bromi* are from Drechsler (1923), and for *P. Avenae* from Dennis (1934). It should be borne in mind that the figures for *P. Lolii* are based on a single collection, and that the material of *P. Avenae* and *P. teres* was limited.

Table 2

	<i>P. Bromi</i>	<i>P. teres</i>	<i>P. Avenae</i>	<i>P. Lolii</i>
Diameter of perithecia	μ 350	μ 500	μ 650	μ 550
Size of asci	300-65	235-33	280-50	185-34
Size of spores	58-25	56-20	56-23	58-18
No. of transverse septa	3	3	3-5 (mostly 5)	5
Ratio: length/width of spore	2.3	2.8	2.4	3.22

These allied species form a series in regard to eccentricity of the spores, and *P. Lolii* has the most narrowly ellipsoidal of the four. The 5-septate spores of *P. Lolii* distinguish this species from *P. teres*, and it differs from *P. Avenae* in the elongated shape of the perithecium, the rather broader setae, the smaller asci, and the more narrowly ellipsoidal spores.

The ryegrass *Pyrenophora* was still pathogenic to *Lolium italicum* after four months in culture and produced indefinite net lesions four to five days after inoculation. (Inocula of two to three spores only.) Attempts were also made to infect barley and oats by leaf inoculation, and by inoculation of seed which was then germinated in silver sand. Barley was not attacked,





but there were indications of slight pathogenicity to oats. This will be dealt with in a later paper.

I am indebted to Miss E. M. Wakefield who kindly prepared the Latin diagnosis, and to Dr R. W. G. Dennis for several useful suggestions.

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EXPLANATION OF PLATE XIV

Figs. 1-6. *Pyrenophora Lolii* n.sp.

- Fig. 1. Three abortive spores and one normal spore in an ascus, living. $\times 600$.
- Fig. 2. Ascus showing remains of five abortive spores, living. $\times 500$.
- Fig. 3. Ascus containing eight normal spores (six are visible at this focus), living. $\times 650$.
- Fig. 4. Indefinite granular tissue from a squashed perithecium, one normal and two abortive spores are visible, living. $\times 300$.
- Fig. 5. Living ascus after twenty-four hours in water, direct germination has taken place of the unorganized ascus contents through the ascus wall. $\times 300$.
- Fig. 6. Net lesion on *Lolium italicum*, from the plot which produced *Pyrenophora Lolii*, living. $\times 3$.
- Fig. 7. *Helminthosporium* spore from the culture which also produced *P. Lolii*. Lactophenol preparation. $\times 700$.

(Accepted for publication 2 April 1947)

OBSERVATIONS ON SAPROLEGNIACEAE

I. *SAPROLEGNIA ANISOSPORA* DE BARY

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(With 23 Text-figures)

Saprolegnia anisospora was described in 1888 by de Bary, who had collected it in the neighbourhood of Strassburg. The species has remained unique among its family from a combination of two outstanding characteristics: (a) the production of giant zoospores (in addition to others of smaller sizes); and (b) the excentric structure of the mature oospores. The latter feature was held in doubt by Coker (1923), who described two forms collected in North Carolina as belonging to this species. Coker described these forms as possessing centric oospores; but in other important characters they appeared to agree closely with de Bary's description. This close resemblance covered a distinctive combination of characters and Coker wrote: 'One is inclined to suspect that de Bary, who rarely made a mistake, was in this case wrong in thinking the normal eggs excentric. His figures clearly show excentric eggs, but may they not have been breaking down? This seems the more likely as no other *Saprolegnia* has an excentric egg.'

I was fortunate enough to isolate this interesting, but little-known, species, and observations were made upon bacteria-free, single-spore cultures over several months. The species was found to agree in detail with de Bary's description, in so far as comparison can be made without recorded measurements of the original form; for de Bary's otherwise careful description included no measurements of the reproductive organs. In particular, it has been possible to confirm the character held in doubt by Coker, namely, the production of oospores having a typical excentric structure. The species has been reported in Latvia by Apinis (1929), who also found excentric oospores. I have found no previous record of the occurrence of this species in Great Britain. Many differences are apparent between the present form and the two American forms described by Coker, and the question of a different oospore structure in the American forms calls for consideration. The following account includes essential measurements made under stated conditions of culture; the form and behaviour of the zoospores is described in some detail; and the character of oospore structure is discussed.

The fungus was isolated from a dead roach (*Leuciscus rutilus*), collected near Haslemere, Surrey. The material was first taken from a patch of felted hyphae on one side of the fish, and a bacteria-free stock culture prepared by growing the fungus upon an agar (Barnes') medium, and removing inoculum from the under-surface of the agar. The sub-cultures

thus obtained were tested by inoculating a liquid maltose-peptone medium (which rapidly became turbid in the event of any persisting bacterial contamination). This medium, which had the composition: maltose 5.0 %, peptone (Parke Davis) 0.1 %, proved useful for maintaining stock cultures over periods of several months without sub-culturing. Single-spore cultures were prepared by using a dummy microscope objective with a cutting tube of small bore, enabling any selected spore to be cut out, together with a small block of agar, from an agar plate. The latter was prepared a few hours previously by 'streaking' the surface with a suspension of encysted zoospores, using a platinum loop of triangular shape. 3 % agar yields a firm gel which does not stick inside the cutting tube.

The following description, except where otherwise stated, relates to observations upon single-spore cultures grown on sterilized hemp seed, in approximately 45 c.c. of sterilized glass (Pyrex) distilled water, within the temperature range 12–16° C. Comparative cultures, in which segments of sterilized mealworm, approximately 1.5 mm. long, were used in place of hemp seed, showed no important differences. Not more than two seeds (or mealworm segments) were used in any one culture vessel. A glass dish, measuring 6 cm. in diameter by 3.5 cm. in depth, with drop-on lid, was the type generally used.

HABIT AND GENERAL COURSE OF DEVELOPMENT

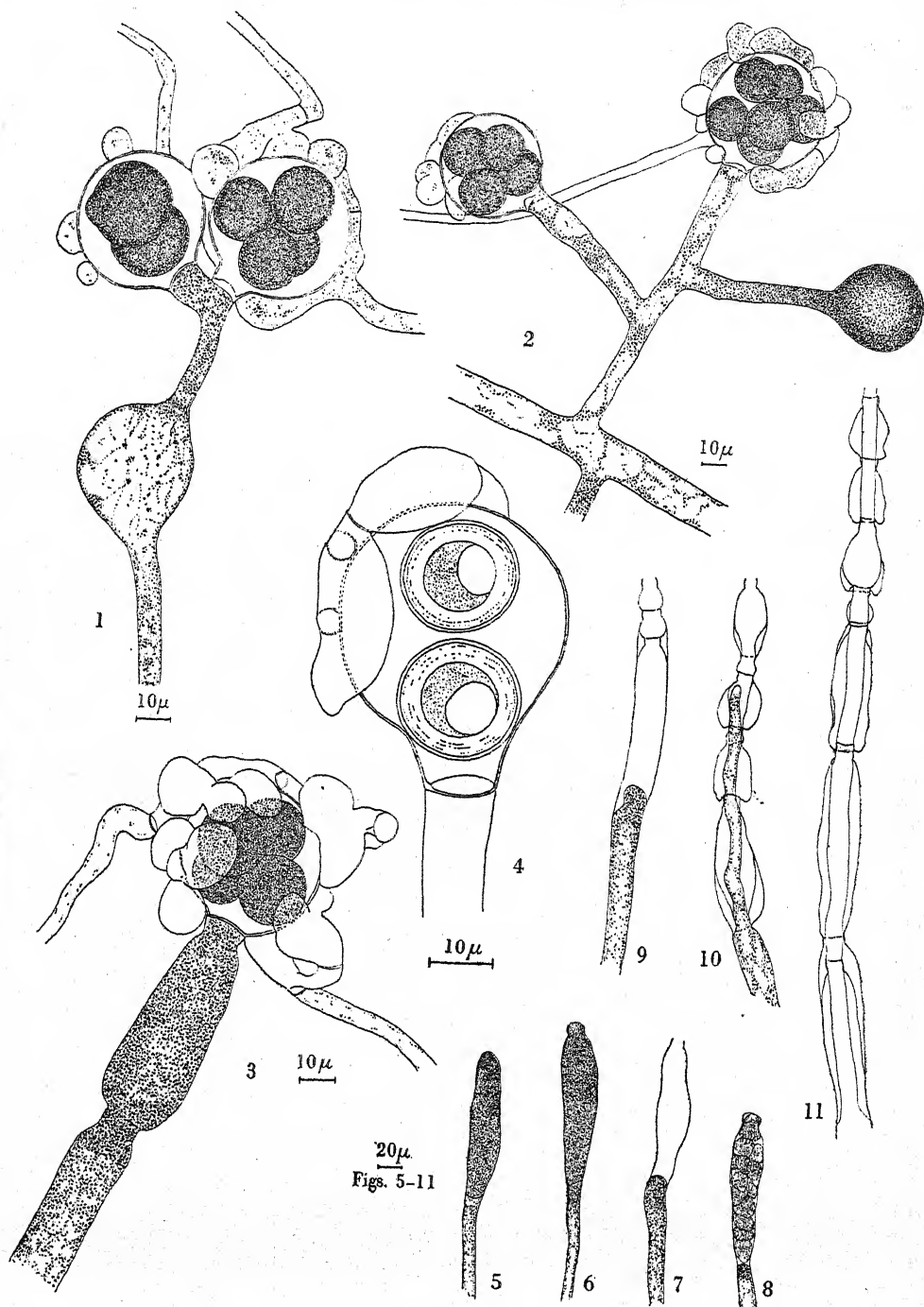
It is felt that this aspect has often received insufficient attention in descriptions of members of *Saprolegniaceae*, many of which show distinctive features in their habit and general course of development when grown upon suitable baits in water-culture.

Under the conditions stated, this species developed a main turf which appeared delicate but tense, relatively short, reaching a length of approximately 4–5 mm. in five to six days and exceeding this only in old cultures of four weeks' growth. Zoosporangia were numerous after three days. Oogonium initials became abundant in five to six days, forming a dense, opaque zone in the outer region of the main turf. In old cultures the limit of the main turf remained well marked by this dense zone, although a delicate outer turf, bearing some gemmae and markedly smaller oogonia, was often present. At a constant temperature of 10° C., the main turf usually reached 5–7 mm. in length and zoosporangia were more abundant; at temperatures between 17 and 20° C., the turf rarely exceeded 4 mm. and few zoosporangia were produced.

ASEXUAL REPRODUCTION

A. *Zoosporangia*

Primary zoosporangia varied from almost cylindrical to a prevalent type which was broadest either above or below the median point and often slightly bent or asymmetrical about the long axis (Figs. 5–8). The majority were between 130 and 195 μ in length and 24–26 μ in breadth, which exceeds the dimensions given by Coker. A well-marked, button-like



Figs. 1-11

papilla at the tip differed from the usual *Saprolegnia* pattern in being comparatively broad, slightly funnel-shaped, and almost flat across the top, where the wall was markedly thin. This contrasted with the remainder of the papilla which had a wall somewhat thicker than that of the sporangium itself (Figs. 8 and 13). Proliferation occurred repeatedly and the first few secondary sporangia were often confined within the empty primary sporangium; later sporangia in the same series commonly showed partial emergence, the protruding part acquiring a characteristic vase-like form and showing a marked tendency, when empty, to become telescoped back upon the preceding sporangium (Figs. 9-11). Long series of proliferated sporangia were invariably found after a few days' growth and were specially evident in cultures grown at 10° C. Secondary sporangia formed by lateral renewal (as in *Achlya*) were comparatively rare.

B. Zoospores

Observations on the present form confirm de Bary's report that all the zoospores from a given sporangium are of the same order of size, and further, that this bears no apparent relation to the size of the sporangium. The zoospores from a given sporangium tend to fall within one of three size-groups: giant, intermediate, or small. In the present form the number of zoospores in any sporangium was never large, commonly between ten and twenty-five, rarely as few as three or four.

(a) First motile stage

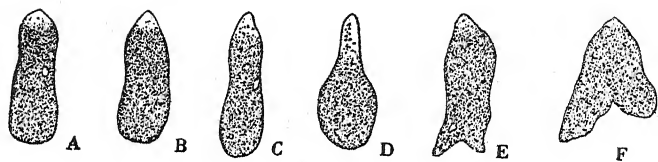
Measurements were made, as rapidly as possible, of spores newly liberated from sporangia. Although such measurements must necessarily be approximate, they have been as far as possible confirmed by subsequent measurements of spores killed with iodine, when, however, a slight contraction occurred.

Table 1. *Dimensions of zoospores*

Zoospores	Giant (μ)	Intermediate (μ)	Small (μ)
1st motile stage: Length	29-32	22-24	13.5-15
Maximum width	10-12	11.5-13	11.5
Encysted zoospores			
1st stage: Diameter	18.5-21	15.5-13.5	

Legends to Figures 1-11

- Fig. 1. Two young oogonia with antheridia associated and with a dilation in the parent hypha.
 Fig. 2. Young oogonia with declinous antheridia.
 Fig. 3. Young oogonium, developed immediately beyond an old zoosporangium, with declinous antheridia associated.
 Fig. 4. An oogonium with mature oospores and with empty antheridia still attached. The oospores show the characteristic excentric structure and the thick two-layered wall, the inner layer showing stratification.
 Figs. 5-7. Primary zoosporangia.
 Fig. 8. Primary zoosporangium containing spores of intermediate type, immediately prior to discharge. The characteristic features of the apical papilla are well marked.
 Figs. 9-11. Zoosporangia in various stages of proliferation. Fig. 9 shows the characteristic vase-like form of the emergent part. Figs. 10 and 11 show the 'telescoping' back of the emergent parts.



12

A

B

C

D

E

F

14

16

A

B

Figs. 12-17

10 μ

15

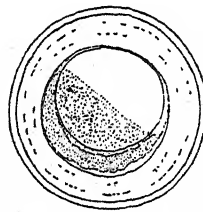
A

B

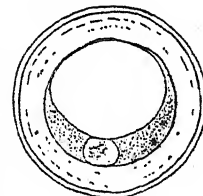
C



17

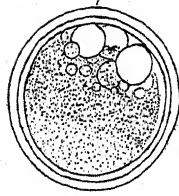


18

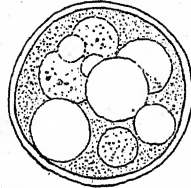


19

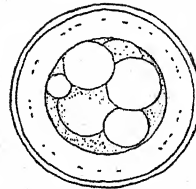
13



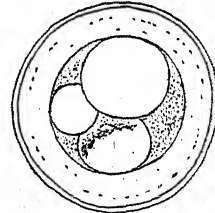
20



21



22



23

Figs. 18-23

10 μ

Figs. 12-23

Cysts of less than 13.5μ diameter were rarely found and it appears probable that spores of both intermediate and small types, when encysted, all belong to the diameter range of $15.5-13.5\mu$. It will be seen that the dimensions of the zoospores fit de Bary's description: 'The largest of these (zoospores) are more than double the size of the smallest, though there are also intermediate forms.' De Bary made no mention of the relative frequency of the smallest spores: in the present case they have been less numerous than the other two types. He described the large spores as 'almost equalling that (the size) of the oospores and having very dense, granular protoplasm'; with which the present form exactly agrees.

The following notes refer to giant and intermediate spores. These showed considerable variety of form in their first motile stage. A large number showed a broadly pointed anterior end and were approximately rod-shaped, or slightly narrower about the middle. Elongate-pyriform and pyramidal forms were also frequent and many of these had their anterior end drawn out into a definite beak. Any of these types occasionally showed two short lobes at the posterior end (Fig. 12). In old cultures, grown at a constant temperature of $10^{\circ}\text{C}.$, some unusually broad, giant spores have occasionally been observed, measuring approximately 27μ in length by 20μ wide. This recalls Coker's description: 'In nearly all cultures there are formed, in addition, a few very large spores at least twice the bulk of the ordinary large spores'; although in the present case these have not been observed to occur as frequently as his statement would indicate. Occasional double spores have been observed: these have two sets of flagella and clearly result from an incomplete cleavage of the protoplasm in the developing sporangium. Coker has figured such compound spores for this species (Coker, 1923; plate 7, fig. 1).

The main body of a zoospore, composed of dense, coarsely granular protoplasm, contrasted strikingly with the usual, delicately granular appearance of zoospores of the Saprolegniaceae. A distinct hyaline area

Legends to Figures 12-23

- Fig. 12 A-F. Giant zoospores. Flagella not drawn. Vacuoles are seen in A, C, E and F.
Fig. 13. Sporangium containing giant spores, just before discharge. The hyaline anterior ends of the spores are seen. Several spores showed active amoeboid movements.
Fig. 14 A-D. Stages in the escape of a zoospore from its primary cyst.
Fig. 15 A-C. Changes in shape of the emerged zoospore (second motile phase), immediately following the events shown in Fig. 14 A-D.
Fig. 16 A, B. Two views of a zoospore during the second (reniform) motile phase, showing the two flagella in Fig. 16 A and the lateral groove from which they arise (Fig. 16 B).
Fig. 17. A zoospore of the first motile phase and of intermediate type, trapped at the opening of the sporangium. The two apical flagella are shown.
Fig. 18. Excentric oospore with thick, two-layered wall and a single, large fat droplet. The protoplasmic contents are limited to a thin, cup-like layer.
Fig. 19. Excentric oospore having a second, much smaller droplet.
Figs. 20 and 21. Immature oospores containing several droplets and with wall still relatively thin.
Figs. 22 and 23. Oospores with characteristic thick wall and apparently near maturity, but containing a few separate fat droplets. Developed at approx. 20°C

occupies the more or less pointed anterior end, from which a pair of long flagella arise. The flagella could sometimes be distinguished momentarily on the living spores, but they became more distinct on spores killed with iodine, when they were seen to exceed the length of the spore body (Fig. 17). The tip of a living spore showed a continuous vibratory motion, apparently related to the movements of the flagella, and also side-to-side movements in a rapid, sensitive manner. The remainder of the spore body commonly showed some capacity for amoeboid change of shape and this was frequently observed even before the spores escaped from the sporangium. In the main body of the spore a few minute, rounded, refractive bodies were often in evidence: the most conspicuous of these was often close within the periphery of the spore, slightly in advance of the middle (Fig. 12 A, C and F). No alteration in the size of this refractive spot could be detected during the brief glimpses offered by the living spores.

The giant zoospores swim comparatively slowly during their first motile stage, revolving at the same time slowly upon their long axis. They were observed to remain in motion for varying periods of five to thirty minutes. They frequently showed an interesting behaviour when coming to rest: the spore was seen to stop, turn itself round shortly, a few times, after the manner of a dog preparing to lie down, and then finally contract into a sphere. Shortly afterwards, a thin cyst wall became discernible.

The small type of zoospore is pyriform and has less dense protoplasm.

(b) *Spore discharge*

Immediately prior to spore discharge, observations on giant and intermediate spores showed distinct amoeboid movements, some of the spores becoming much elongated in attempting to make their way between neighbouring spores in the sporangium. At this stage the hyaline anterior ends of the spores were usually clearly distinguishable, some pointing towards the tip of the sporangium, others in the opposite direction (Figs. 8 and 13). Thus, except in the broadest part of the sporangium, the spores of either of the two larger types commonly lay two abreast, pointing in opposite directions, while at the basal end of the sporangium two or three spores were usually arranged in single file.

The topmost spore was frequently placed with its anterior end pointing away from the tip of the sporangium. In many such cases it was observed to make energetic attempts to turn round during the few minutes immediately preceding spore discharge. When this attempt proved successful, the spore moved up until its tip came into contact with the thin end wall of the papilla. In several cases the hyaline tip was drawn slowly over the inner surface of the end wall, until it rested in the angle made with the thicker side wall. Here it would remain until the liberation of the spores occurred. At the base of a sporangium, the lowest spore was frequently seen, several minutes before discharge, to be separated from the basal septum by an obvious gap; several of the spores at this end of the sporangium showed considerable freedom for amoeboid movement.

The thin end wall of the papilla became indistinct, then finally was no longer discernible under a one-sixth-inch objective. Almost at once the

spores emerged in a steady succession, not explosively. As each spore made its way through the open papilla it became somewhat constricted, and often remained somewhat dumb-bell shaped for a few seconds after release. After the first few spores had escaped, the later ones moved up to the opening more slowly. As far as could be discerned, a spore showed no connexion with others during spore discharge; and the last spores to emerge were often widely separated as they passed slowly up to the opening.

(c) *Second motile stage*

The escape of the second motile stage from cysts measuring approximately 18.5μ in diameter was observed (Figs. 14 and 15). It was usually accomplished in one to two minutes; but in some instances the spore, having emerged, then remained just outside the cyst wall for a further period of as much as thirty minutes, before beginning to swim: during this period it was almost stationary, except for slight rocking movements. (It is possible that such delay before beginning to swim may have been caused by the light or temperature conditions upon the microscope stage.) In the second motile form the spores showed the same coarsely granular appearance of the protoplasm. They were ovoid, with slightly pointed ends and a lateral groove running back from the anterior end almost the entire length of the spore body. A median pair of long flagella arose from this groove (Fig. 16). Typical dimensions were as follows: a larger type, length $18.5-20.5\mu$, width $12-13.5\mu$; a smaller type, length 15μ , width 12μ . The spores swim much more rapidly than in the first stage, also revolving quickly upon their long axis. Spores emerging from some cysts which had become fortuitously imprisoned inside an empty sporangium were observed to swim persistently backwards and forwards, exploring repeatedly the inner surface of the sporangium wall, and showing some capacity for momentary change of shape when reversing direction. The spores have been observed to remain actively swimming for upwards of thirty minutes, or in other cases to come to rest relatively soon. After rounding off, each spore formed a spherical thin-walled cyst of approximately the same size as that from which it emerged.

In most cultures, a small proportion of cysts measuring only $12-12.5\mu$ has been observed. In some cultures, three to four weeks old, which had been kept at a temperature of 10°C. , such small cysts were relatively numerous and had settled in large groups upon some of the older hyphae. They appeared to have relatively scanty protoplasmic contents and some showed a slender, short germ-tube. It was not possible to determine if these small cysts were produced as a consequence of a polyplanetic behaviour under the conditions mentioned.

(d) *Spore size in relation to single-spore cultures*

De Bary made single-spore cultures from giant spores and reported that these cultures gave rise to plants which showed the normal behaviour in producing zoospores of various sizes. A long interruption in the present work resulted in the loss of the stock cultures and prevented this point from

being confirmed. Once only, a culture used for detailed observation had been made from an encysted spore of known diameter. The cyst diameter was 13μ and the cyst may therefore be taken as belonging to a spore of the small type. This gave rise to a plant which made a completely normal development and produced giant spores as well as intermediate and small ones. This observation is thus complementary to de Bary's report.

SEXUAL REPRODUCTION

A. *Oogonia and antheridia*

Oogonia were mostly spherical or sub-spherical, having a short neck or almost sessile, and appearing very early. The first oogonia were mainly terminal, but by the sixth day others were appearing on lateral branches and slightly later on lateral branch systems of cymose type. They formed a dense zone in the outer region of the main turf. The majority fell within the diameter range, $40-52\mu$, and contained two to six, or more, ova, commonly four or five. The oogonium wall was smooth, moderately thin, without visible pits (Figs. 1-4). A dilation of the hypha, some short distance below a terminal oogonium, or at a point of forking below two terminally borne oogonia, was frequently observed, and appears to be fairly characteristic of the species (Fig. 1).

Antheridia were diclinous and developed early on long, relatively slender hyphae, which later disappeared leaving the empty antheridia clearly distinguishable; at least two, frequently several, antheridia were associated with each oogonium, becoming closely wrapped about it, often to a large extent hiding the oogonium. The antheridia were commonly broad or appeared somewhat inflated, frequently lobed (Figs. 1, 3 and 4). Two or three broad, cushion-like 'feet' were sometimes visible where the antheridium was applied to the oogonial wall. The antheridial hypha often continued its growth, thus reaching a second or subsequent oogonia. An antheridial (fertilization) tube was observed in a few instances.

B. *Oospores*

The oospores at maturity varied from 16 to 24μ in diameter, most being $18-21\mu$. Apart from the excentric structure, the markedly thickened wall is another outstanding feature. In mature oospores the wall was $3-3.5\mu$ in thickness and distinctly two-layered: the refractive outer layer was approximately one-sixth of the total thickness (or a greater proportion in some instances which were apparently immature). The inner layer appeared denser, less refractive, and usually showed a faint, concentric stratification (Figs. 4, 18 and 19).

In most mature oospores the contents showed a typical excentric structure, essentially similar to that which is characteristic of numerous species of *Achlya*: the single lateral oil droplet was somewhat elliptical and the protoplasm of exceedingly fine, granular consistency (Fig. 4). In some instances, however, the oil droplet was much larger, occupying the greater part of the interior and limiting the protoplasm to a relatively narrow

crescent as viewed in optical section (Fig. 18). Other conditions were also observed, in which two or more smaller oil droplets were present instead of a single larger droplet, but these were frequently grouped to one side of the protoplasm, i.e. upon an excentric plan (Fig. 20). Since the wall of these multi-droplet oospores was relatively thin, it is suggested that they represented immature stages, in which the several oil droplets had not yet coalesced.

The occurrence in old cultures, however, of oospores, with a thick, two-layered wall, and containing several oil droplets, often of varied sizes, indicates that a proportion of the oospores may never acquire a typical excentric structure (Figs. 22 and 23). Here it may be recalled that species of *Achlya* which typically possess excentric oospores, may at times show other types having two or more smaller droplets (Coker, 1923; plate 35, fig. 5; plate 49, fig. 12). In the present species, at temperatures ranging from 17 to 22° C., oospores of the typical single-droplet, excentric pattern have been noticeably less frequent. Under these conditions, the maturation of the oospores becomes more rapid, the oospore wall quickly thickens to the maximum observed, and the several oil droplets present may show no indication of coalescence. It therefore appears that a more gradual development is most favourable for excentric structure.

Oospores of the true excentric type have developed equally well in hemp-seed and mealworm cultures, also in two liquid media which were tried, viz.:

Solution 1. Maltose 0.0125 % plus Witte's peptone 0.025 %.

Solution 2. Maltose 0.025 % plus Witte's peptone 0.025 %.

DISCUSSION

Regarding the unique character of this species de Bary wrote: 'It is distinguished from all others by the structure of the ripe oospores, which resemble those of *Achlya polyandra*. Along with this, there is the altogether peculiar feature of two kinds of sporangia, the one like those of allied species, the other forming giant zoospores. The largest spores are more than double the size of the smallest, but there are also intermediate types. The spores are all of one size in any one sporangium. There is no relationship between the size of a sporangium and that of its spores: sporangia of equal size will form spores of quite different dimensions.' The present investigation serves to re-establish the altogether singular position of this species. The two forms described by Coker show many points of resemblance to de Bary's species. The one apparent discrepancy lies in the structure of the oospores, which Coker has described as centric. His figures (Coker, 1923, plate 9, fig. 4), however, fail to convince me upon this point: thus, along with two apparently centric oospores, there is shown in the same oogonium an oospore which has eight conspicuous droplets grouped on one side of the protoplasm. This latter instance is not unlike immature stages which have been observed in the present form. It may be noted that none of the oospores figured by Coker shows the markedly thick wall which develops in the mature oospores of the present form, nor are they as thick-walled as those drawn by de Bary. From this it may perhaps be inferred that, in the

American forms, the oospores were slow to mature, and that those studied by Coker were still relatively immature.

There are other differences in the American forms which are summarized in Table 2:

	Zoospores: diameter of 1st encysted stage			Diameter of oospores	
	Giant (μ)	Intermediate (μ)	Small (μ)	Range (μ)	Majority (μ)
American forms (according to Coker)	13.7-14.8	10.5-11.5	8-9	17-38	21-27
Present form	18.5-21	15.5-13.5		16-24	18-21

Coker described his forms as developing secondary sporangia by lateral renewal (as in *Achlya*) when grown in distilled water, but in spring water proliferation was as usual in *Saprolegnia*. The latter method has been found typical of the present form when grown in distilled water, prepared in a Pyrex glass still. Further, oogonia borne in chains have never been observed in the present form; they were figured by Coker, but no details were given of the medium on which they were developed. The oogonia of Coker's Form B are larger than those of the present form, but those of his Form A show a closer agreement.

These differences of size may, however, be regarded as of minor significance when set against the combination of characters in which these American forms show agreement with de Bary's species (including the present form). Coker summarized these characters: 'The small oogonia with unpitted walls, the small number of eggs, the numerous and conspicuous declinous antheridia on each oogonium, and the very variable spores.' Observations upon oospore-development in the present form strongly indicate that, if the mature oospore structure of Coker's forms were better known, they would be found to coincide also in this character; and thus to possess both those characters which mark out *Saprolegnia anisospora* as unique in its family.

SUMMARY

A detailed study of a strain of *Saprolegnia anisospora* collected at Haslemere, Surrey, showed that it agreed in detail with de Bary's original description of the species.

In particular, the formation of oospores having a typical excentric structure has been confirmed. In this character, and in the production of zoospores of at least three size-groups, *S. anisospora* stands unique in its family.

Detailed observations on the zoospores are recorded.

The apparent difference in the American forms, described by Coker, in relation to oospore structure, is discussed.

The main characteristics, as observed in hemp-seed cultures, grown in 45 c.c. of glass (Pyrex) distilled water, at 12-16° C., may be summarized as follows:

Main turf 4-5 mm. Primary zoosporangia widest above or below the

median point, often slightly curved or asymmetrical: majority $130-195 \times 24-26\mu$. Terminal papilla broad, flat across the top, and having a thicker side wall. Proliferation occurs repeatedly, with partial emergence, empty protruding portions becoming telescoped back. *Zoospores* commonly 10-25, and all of the same order of size, from any one sporangium: dipplanetic. Three size groups were distinguished: giant, intermediate and small. Giant zoospores measured $29-32 \times 10-12\mu$, their cysts $18.5-21\mu$ in diameter; their protoplasm is dense and coarsely granular and they show considerable amoeboid movement. *Oogonia* developed early and formed a dense zone in the outer region of the main turf, at first borne terminally, later in cymose, lateral groups: majority $40-52\mu$ in diameter, having usually 2-6 ova, wall not thick, unpitted. *Antheridia* declinuous, broad, several to each oogonium. *Oospores* typically excentric, having a thick, two-layered wall; majority $18-21\mu$ in diameter.

In conclusion, the writer wishes to record his thanks to Prof. F. T. Brooks, F.R.S., and to Prof. F. E. Fritsch, F.R.S., for advice and criticism; also to Mr J. F. Leney, of Haslemere, who sent the specimen.

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OBSERVATIONS ON SAPROLEGNIACEAE

II. *SAPROLEGNIA PARADOXA* MAURIZIO

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(With 6 Text-figures)

This species, described in 1899, was originally isolated from eggs of the sea-trout. Since Maurizio's original investigation it has remained comparatively unknown. The only published record of its occurrence in Great Britain (Brown, 1938) makes no reference to those peculiar egg-containing structures, resembling antheridia or androgynous antheridial branches, which appear in this species. Maurizio furnished his account with only a single figure of these interesting structures.

The present account records observations made upon single-spore cultures of this species. The fungus was isolated from a dead roach (*Leuciscus rutilus*) collected at Haslemere, Surrey, the material having been taken from a small patch of felted hyphae on the head of the fish. The fungus agreed well with Maurizio's description and in the later stages of fruiting showed the anomalous egg-containing structures already mentioned. Except where otherwise stated, the following notes refer to single-spore cultures, prepared from bacteria-free stock culture, and grown on sterilized hemp seed in 45 c.c. of sterilized glass (Pyrex) distilled water, not more than two seeds being used in any one culture dish. The development of the fungus upon small segments (1-2 mm. long) of mealworm, but under otherwise identical conditions, was found to be essentially the same.

GENERAL CHARACTERISTICS

The main turf became well developed in six to seven days within a temperature range of 12-16° C., reaching an average length of approximately 7 mm. Later, a delicate outer zone develops, extending above the main turf to approximately 1 cm. above the hemp seed. In twelve to fourteen days after the beginning of the culture, a deep zone in which numerous oogonia and antheridia are developed becomes easily visible in the outer half of the main turf, and is conspicuous by the twenty-first day. A few spherical, gemma-like bodies, somewhat smaller than oogonium-initials, but with dense protoplasmic contents, are usually developed on the relatively slender hyphae of the outer zone; some are borne in series of two.

The reproductive organs showed close agreement with Maurizio's description upon most essential points. Intercalary oogonia, however, were comparatively rare, and none of the elongated, thread-like pattern, mentioned by Maurizio as containing up to seventeen ova in a row, was

found. Oogonia were, for the most part, spherical or sub-spherical, with or without a short neck, and mostly borne on short, lateral branches. The maximum number of ova observed was fifteen. Maurizio reported the number of ova in intercalary oogonia as, in some cases, approaching fifty; and Miss Brown (1938) has figured oogonia containing considerable numbers of ova, from a strain collected in the neighbourhood of Aberystwyth. This strain was ascribed to *Saprolegnia paradoxa*, although no antheridia were described.

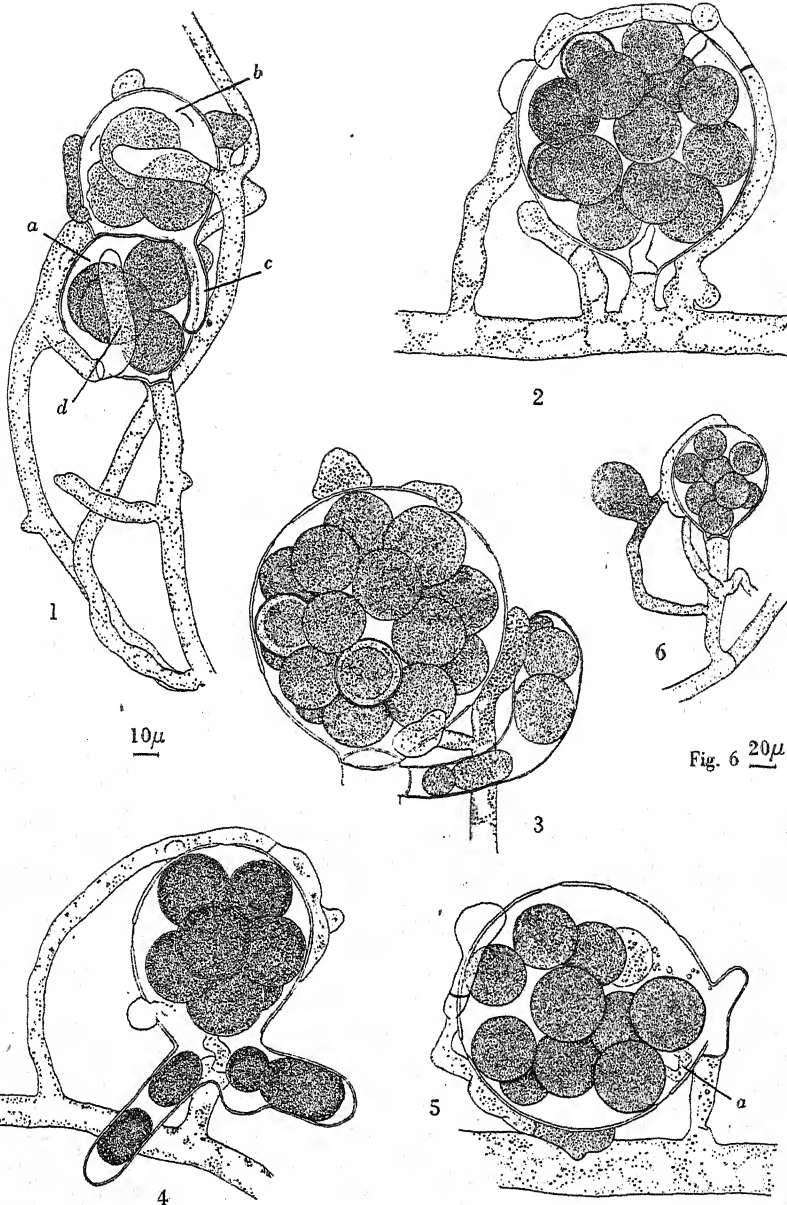
In the present form, every oogonium became associated with one or more, commonly three or four antheridia. These, as in Maurizio's description, were mainly of androgynous origin. They were typically borne on short, curving branches, arising from the oogonial branch, or from the main hypha close by (Figs. 2 and 4). Sometimes, however, diclinous antheridia, borne on relatively long hyphae, were present together with androgynous ones on the same oogonium. The prevailing type of antheridium was club-shaped, with a well-marked angular bulge on the dorsal side. Often, an antheridium showed two or more lobes; and short, blunt, foot-like processes were commonly seen on the side applied to the oogonium wall.

Maurizio's description indicates that the oospores showed a variable internal structure. In the present form, a well-marked sub-centric pattern was much in evidence, but others varied to an approximately centric type. The individual oil droplets appeared to be less distinct than is usual among Saprolegniaceae, even when viewed with a $\frac{1}{2}$ inch oil-immersion objective. One curious double, or compound, oospore was found.

SPECIAL VARIATIONS OF OOGONIA AND ANTHERIDIAL BRANCHES

In the later stages of fruiting, after two to three weeks' growth, and more commonly, though not exclusively, at the higher temperatures employed (17–20° C.), a proportion of the oogonia was found to have anomalous structures associated with them. These usually had the form of one or two egg-containing outgrowths, arising either from the main body of the oogonium, close to the neck, or directly from the short neck itself. When relatively short, these outgrowths stand off stiffly from the oogonium (Fig. 4), smaller ones often being somewhat narrowed at the base. The longer type usually arise from the oogonial neck, or immediately below the basal septum. They were frequently club-shaped, and curved upwards so as to bring the distal portion into contact with the oogonium wall. This type is therefore somewhat reminiscent of an androgynous antheridium (Fig. 3). The number of ova in a single outgrowth varied between one and several; the ova were somewhat smaller than the average size within the oogonium proper, were arranged in a single row, and often laterally compressed to an elliptical form. The wall of an egg-containing outgrowth was thickened like that of an oogonium and pit areas were observed in some cases.

A small proportion of oogonia were borne on short branches which were bent at an angle of almost 90° close beneath the oogonium, the point of the



- Fig. 1. Young oogonium (*a*) with androgynous branches arising from its hypha. One of these shows an oogonium (*b*) with a prolongation (*c*) clasping the original oogonium, also an antheridium-like development (*d*).
- Fig. 2. Oogonium with androgynous antheridia associated. An antheridial (fertilization) tube is visible and two of the ova show internal differentiation, also thickening of the wall, indicating oospore development. The oogonium has a basal ingrowth.
- Fig. 3. Oogonium with a single egg-containing outgrowth which has arisen from immediately beneath it. An antheridial branch is associated with the oogonium.
- Fig. 4. Oogonium with two egg-containing outgrowths near the base and with one antheridial branch associated. An antheridial tube and a basal ingrowth are shown.
- Fig. 5. Oogonium inclined at right angles to its stalk and having a short projection from the point of the angle. Part of an antheridial tube is seen within the oogonium at (*a*).
- Fig. 6. Oogonium with androgynous antheridial branches associated, one of which is developing a lateral swelling which resembles an oogonium initial.

angle being frequently extended as a slight projection (Fig. 5). Such knee-like oogonial branches appear to be quite characteristic of this species and are mentioned by Maurizio. In the present form, the projecting knee-joint had, in some cases, all the appearance of a feeble attempt to form the type of anomalous outgrowth already described, although in no case was such a projection large enough to have contained ova.

The resemblances which some of the egg-containing outgrowths bear to androgynous antheridial branches have been mentioned. Other examples were observed in which an androgynous branch developed an egg-containing structure in addition to one or more antheridia. In these, the egg-containing organ usually took the form of an asymmetrical swelling in a branch which was otherwise of average width. Such a swelling was comparable in size to a small oogonium, had a similarly thickened and pitted wall, and contained usually not more than two or three ova. On the same branch, either above or below this structure, an antheridium was commonly developed, which became applied to the wall of the oogonium proper (that is, with which the androgynous branch was associated) (Figs. 1 and 6). In some cases, antheridia were seen to be applied to the egg-containing structure itself, these antheridia arising on other androgynous branches, or on diclinous branches. In one of these cases an antheridial tube was clearly visible. The irregularly knotted character of antheridial branches, described by Maurizio, was not observed.

An attempt was made to stimulate the production of these anomalous androgynous branches by growing the fungus in certain liquid media. Three of the solutions used (Nos. 1 to 3) are reported to have stimulated the development of antheridia and antheridial branches in other species (Klebs, 1899; Kauffman, 1908); solution 4 has yielded excellent crops of antheridia and oogonia with *Saprolegnia parasitica* and *Sap. anisospora*. The compositions of these solutions are as follows:

- Solution 1. Leucin 0.1 % plus tri-potassium phosphate 0.1 %
- Solution 2. Leucin 0.1 % plus potassium nitrate 0.1 %
- Solution 3. Laevulose 0.1 % plus tri-potassium phosphate 0.1 %
- Solution 4. Maltose 0.025 % plus Peptone (Witte's) 0.025 %

None of these solutions had any effect in the direction required. They were, in fact, less successful in this respect than hemp-seed cultures. The lowest temperature range employed was 10–13° C., the highest 17–20° C. Abundant oogonia and antheridia were produced in solutions 3 and 4, the antheridia being in both cases mainly diclinous. In solution 3 occasional oogonium-like swellings on antheridial branches were observed; in solution 4 an occasional oogonium with a short protrusion was found, but no egg-containing outgrowths were present. In solution 4 the antheridia showed a strong tendency to be lobed or branched. Sometimes the antheridial branch forked immediately below the antheridia; in others, the branch remained simple, but the antheridium showed two, three or more relatively long lobes. The oogonia produced in solution 4 were practically indistinguishable from normal oogonia grown on hemp seed; in solution 3, however, the oogonia showed a marked difference in that the majority had

a pronounced neck, frequently $12-17\mu$ in length, in which one or more ova were tightly wedged. A few intercalary oogonia were developed in solution 4, but they were not of the elongated pattern described by Maurizio. Well-developed oospores were formed in both these solutions, although more tardily in solution 3.

SUMMARY

An account is given of some of the anomalous egg-containing structures observed during a study of this species, grown in single-spore culture on hemp seed. An attempt to stimulate their production by the use of synthetic liquid culture media is noted.

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(Accepted for publication 27 May 1947)

OBSERVATIONS ON THE GENUS *MYROTHECIUM*II. *MYROTHECIUM GRAMINEUM* LIB. AND TWO NEW SPECIES

By N. C. PRESTON

(With Plates XV and XVI and 5 Text-figures)

INTRODUCTION

Three species of *Myrothecium* are dealt with here. Two of these, which are referred to in a previous paper (Preston, 1943), have not been previously described and are considered to be new. The third, *Myrothecium gramineum*, was originally named by Libert (1837) on the printed label of a published *exsiccatum*. This species has been critically examined afresh and a fuller diagnosis of it is now presented.

Myrothecium gramineum Lib.(i) *Material studied and characteristic features.*

Two collections of this species have been available.

(a) An authentic Libert collection published in Pl. Crypt. Ard. exsic. No. 380 on decaying grasses in Herb. R. B. G. Kew. The original description on this packet reads as follows: *Myrothecium gramineum. Minutum rotundum in ambitu pilis erectis albis ciliatum; disco subturgido nigro; sporidiis cylindricis. In Gramineis putrescentibus. Aestate.*

(b) On *Pennisetum subangustum*; Makene, Sierra Leone; F. C. Deighton (M. 1743); 28. i. 1939 from Herb. Imp. Myc. Inst. No. 1494.

The most characteristic feature of *M. gramineum* is the very stout and usually aseptate setae (see Text-fig. 1A) which fringe the sporodochium. These make it readily distinguishable from the new species, next described, which has somewhat similar spores (see Text-fig. 2) but the setae of which are comparatively slender and always multiseptate.

(ii) *Revised description*

Mycelium (on potato-dextrose agar). Pure white, forming a dense growth. Hyphae thin-walled, hyaline, septate; subaerial filament cells $20 \times 3-4\mu$, aerial filament cells $20 \times 1-2\mu$. *Sporodochia*. Circular or elliptical, saucer-shaped, sessile, 0.2-0.9 mm. in diameter, 0.1-0.17 mm. deep. Black, surrounded by a fringe of numerous long, white, thick-walled setae. *Setae*. Straight, hyaline, tapering, ending in an acute or bluntly rounded point, generally continuous but occasionally with a single septum near the lower end about 40μ above the base; 200 to about 400μ in length, $10-20\mu$ wide near the rounded base and about 4μ just below the tip, walls 3μ thick at base tapering to about 1μ at tip, inner surface of wall often slightly sinuous, outer surface occasionally so. *Conidiophores*. Composed of fertile hyphae and phialides. *Fertile hyphae*. Sub-hyaline, septate, oliveaceous in the mass, 2-3 μ wide with the terminal (or sub-phialide) cells

slightly broadening at the distal end; so closely intertwined as to be almost inseparable and forming a very compact sub-hymenial disk. *Phialides*. Hyaline, straight or flexuose, slightly clavate or sub-cylindrical, $8-15 \times 2\mu$; generally arising in whorls of three or more from the terminal cells of the fertile hyphae; those arising from the lower filaments longer than those from the uppermost ones, the whole forming a dense palisade-like layer in which the individual phialides are very difficult to distinguish. *Conidia*. Continuous, sub-hyaline or pale green, narrowly ovate, ends rounded or with the broader end occasionally slightly flattened, $7-10 \times 2\mu$, average $8.5 \times 2\mu$.

Myrothecium jollymannii n.sp.

(i) *Material studied and characteristic features*

The type isolation of this species was originally made by F. W. Jollyman in 1936 from dried tobacco leaves in Nyasaland. A transfer was received from the Imperial Mycological Institute as Jollyman 145, 14. ix. 36. Further transfers from this have provided all the material upon which this description is based.

The sporodochia bear a close superficial resemblance to those of *M. inundatum* and of *M. gramineum* owing to the fringe of stiff white setae which is common to each. The setae, however, are much more slender than those of *M. gramineum* and are multiseptate. They usually consist of seven to ten cells whereas those of *M. inundatum*, which are even more slender, rarely show more than five cells and the much more robust setae of *M. gramineum* are either continuous or have but a single septum a short distance from the base. The conidia are much larger than those of *M. inundatum* and more rod-like than those of *M. gramineum*, to which, however, they approximate closely in size.

The brown sub-hymenial layer further distinguishes this species from any of those so far described in these studies; it occurs also in the new species *M. striatisporum*, next to be described, which, however, has very characteristic and easily recognizable conidia.

Sub-cultures sometimes produce a wrinkled growth with very scanty aerial mycelium, if any at all, and usually without sporodochia.

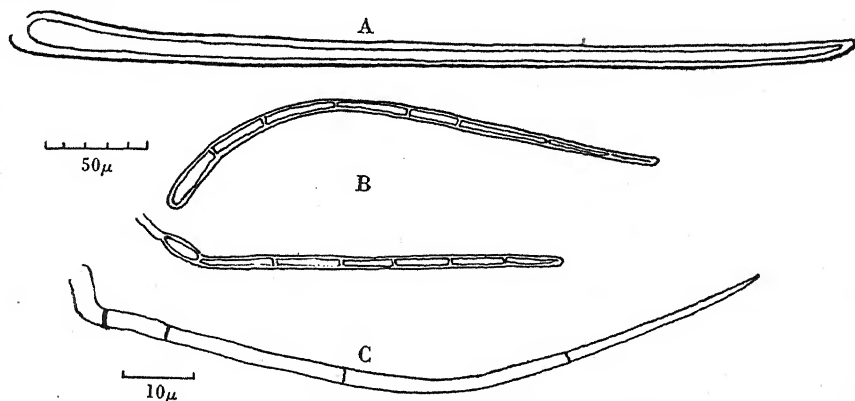
Myrothecium jollymannii is a potential parasite since, like the British *M. roridum*, it readily attacked the living leaves and stems of *Viola cornuta* when spore suspensions were applied to detached shoots placed in a moist chamber.

(ii) *Description*

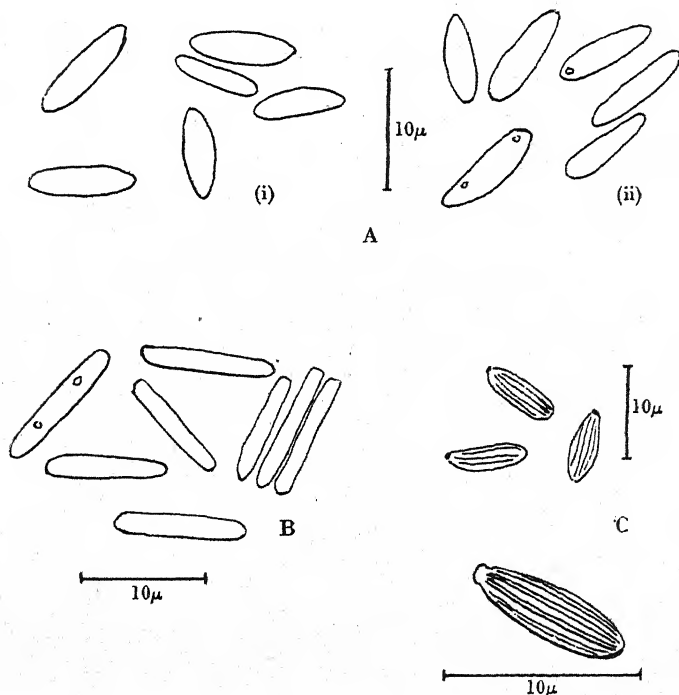
Myrothecium jollymannii sp. nov.

Mycelium ex hyphis hyalinis, tenuiter tunicatis, septatis compositum. *Sporodochia* orbiculata, sessilia vel brevissime stipitata, cupuliformia, 0.3-1 mm. diam., rarius ad 2 mm. diam. primo viridia demum atra, margine albido e setis hyalinis multiseptatis, crassetunicatis composito. *Setae* saepius $100-200\mu$ longae, $5-8\mu$ latae, $6-9\mu$ septatae. *Conidiophora* ex hyphis fertilibus phialidibusque composita. *Hyphae fertiles* olivaceo-brunneae, irregulariter ramosae, dense intertextae, discum compactum

obscuratum efficientes, septatae, infra septa paullo dilatatae, cellulis terminalibus quam basalibus brevioribus. *Phialides* subhyalinae, rectae vel curvulae, leviter clavatae, $12-15 \times 2 \mu$. *Conidia* continua, pallide olivaceo-brunnea, cylindrica vel paullo angustata, apicibus obtusis, praecipue biguttulata, $8-12 \times 2.5 \mu$.



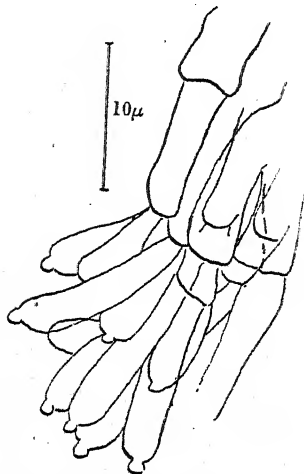
Text-fig. 1. Setae. A, *M. gramineum* Lib.; B, *M. jollymannii* n.sp.; C, *M. striatisporum* n.sp. (A and B $\times 320$; C $\times 1200$.)



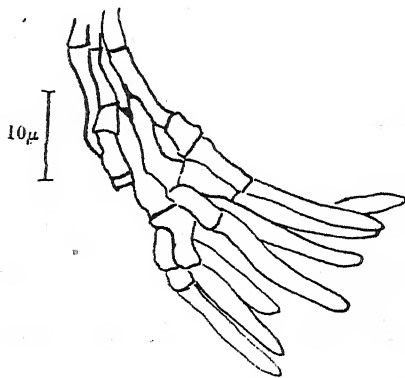
Text-fig. 2. A, *M. gramineum* Lib.: (i) spores ex Deighton M1743, (ii) spores ex Libert no. 380, 1837; B, *M. jollymannii* n.sp., spores ex potato-dextrose agar; C, *M. striatisporum* n.sp., spores ex cherry agar.

Hab. Ex foliis siccantibus *Nicotianae tabaci*, in Nyasaland, Africa, in anno 1936 isolatum (F. W. Jollyman No. 145) et in agar excultum et descriptum. Pars exsiccata in Herb. I. M. I. deposita sub. no. 1495 est typus.

Mycelium. Hyphae thin-walled, colourless, $1-3\mu$ wide; septate cells usually $10-15\mu$ in length. On artificial media sometimes forming a wrinkled growth closely appressed to the medium and consisting of tinted



Text-fig. 3. *M. jollymannii* n.sp. Phialides from potato-dextrose agar culture.



Text-fig. 4. *M. striatisporum* n.sp. Phialides.



Text-fig. 5. *M. striatisporum* n.sp., approx. $\times 20$. Sporodochium showing contorted fringing hyphae. Freehand drawing under Leitz 'Ultrapak'.

hyphae about 3μ wide of a pale brown, orange or pinkish colour, surmounted by a sparse aerial cottony growth, always pure white, consisting of slender colourless hyphae $1-2\mu$ in width. *Sporodochia.* Circular, sessile or very shortly stipitate, cup-shaped, $0.3-1$ mm., or occasionally 2 mm. in diameter, $0.15-0.2$ mm. deep. Green at first becoming velvety black, surrounded by a rim of thick-walled, multiseptate, hyaline setae which at first curve inwards, then straighten. *Setae.* About $100-260\mu$ long $\times 5-8\mu$ wide, tapering to a blunt rounded point; usually of seven to ten cells which vary from $18-26\mu$ in length with walls about 1μ thick. *Conidiophores* com-

posed of fertile hyphae and phialides (Text-fig. 3). *Fertile hyphae*. Olive brown, irregularly branched, septate, cells $8-15 \times 2-4\mu$ broadening slightly below the septa, the terminal cells shorter than the basal ones. Very closely intertwined forming a dark-coloured disk. *Phialides*. Sub-hyaline, straight or slightly curved, slightly clavate, $12-15 \times 2\mu$. *Conidia*. Continuous, pale greenish brown, straight-sided, cylindrical or more usually very slightly tapering with blunt ends, the broader end flat the narrower end often somewhat rounded, generally biguttulate, $8-12 \times 2.5\mu$, average $10 \times 2.5\mu$.

Type isolation. From dried tobacco leaves, in Nyasaland, Africa, 1936 (F. W. Jollyman No. 145).

***Myrothecium striatisporum* n.sp.**

(i) *Material studied and characteristic features*

This fungus was originally isolated by J. C. Neil (No. 582) from a clay soil in New Zealand. A sub-culture of Neil's isolate was obtained through the Imperial Mycological Institute and this, together with subsequent transfers, has formed the basis of the present description.

The sporodochia of this species (Text-fig. 5) are superficially indistinguishable from those of *M. roridum*, the white fringe being composed of twisted hyphae among which the presence of setae is very exceptional. Only once have any setae been found among the many hundreds of sporodochia examined (Text-fig. 1C).

Microscopically this species is readily distinguished by its striate, or fluted, conidia which are generally sub-fusoid though occasionally approximating to rod-shaped. It is further distinguishable from either *M. roridum* or *M. verrucaria* by the dark colour of the hymenial layer, and by the characteristic dark brown sterile filaments which are frequently found interspersed among the fertile hyphae, often extending beyond the general surface of the disk.

(ii) *Description*

Myrothecium striatisporum sp.nov.

Mycelium ex hyphis hyalinis, tenuiter tunicatis, septatis $1-2\mu$ diam. compositum. *Sporodochia* minuta, tenuiter cupuliformia, orbicularia vel irregularia, $0.05-0.2$ mm. diam. saepe confluentia, primo viridia demum aterrima, margine albido ex hyphis contortis, hyalinis, tenuiter tunicatis, aliquanto latioribus composito. *Setae* rarissimae. *Conidiophora* ex hyphis fertilibus phialidibusque composita. *Hyphae fertiles* brunneo-tinctae, praecipue 3-septatae, irregulariter infra septa ramosae; ramis sursum dense intertextis, discum obscurum efficientibus; adsunt quoque hyphae steriles, non ramosae, atrobrunneae, inter hyphae fertiles crescentes. *Phialides* e subhyalino olivaceae, vel terminales vel e geniculo cellulae primogenitae oriundes, tenuissime clavatae, $7-22 \times 3\mu$. *Phialides terminales* semper ceteris breviores. *Conidia* subhyalina deinde olivaceo-brunnea, continua, subfusioidea, apice acuta, basi minute apiculata, episporio primo laevi demum longitudinaliter striato ornata, 7×2.5 ad $12 \times 3.5\mu$ (av. $9.6 \times 3\mu$).

Hab. Ex terra argillacea sub agro pascuo, in Nova Zealania in 1937

isolatum (J. C. Neil 582) et in agaro excultum et descriptum. Pars exsiccata in Herb. I. M. I. deposita sub. no. 1526 est typus.

Mycelium. Pure white. Hyphae hyaline, slender $1-2\mu$ wide, thin-walled, septate; cells $15-25\mu$ long. *Sporodochia*. Minute shallow cups, circular or irregular, $0.05-0.2$ mm. in diameter, about $0.05-0.1$ mm. deep and often confluent into larger masses. Composed of loosely arranged hyphae, arising from a compact or pseudoparenchymatous base, and terminating in a dense disk-like layer. Green at first, becoming jet black surrounded by a white rim of rather broad, thin-walled, contorted, hyaline hyphae. *Conidiophores* composed of fertile hyphae and phialides (Text-fig. 4). *Fertile hyphae*. Tinted brown, consisting of a main axis usually of three cells with branches arising irregularly from below the septa and very closely intertwined. Cells $3-13\mu$ long by about 2μ wide, the terminal cell always shorter than the others. Interspersed by unbranched, sterile, dark brown, thick-walled, somewhat sinuous filaments, $3-4\mu$ wide and 40μ or more in length (the walls of which frequently appear verrucose). *Phialides*. Sub-hyaline to pale olive green, greenish brown in the mass, arising terminally or from a geniculation of the parent cell, very slenderly clavate, rather thick-walled, $7-22 \times 3\mu$. The terminal phialides short, straight or slightly flexuose, the lateral ones longer and bent sharply near the base, the whole thus forming a closely packed, even, hymenial layer. *Conidia*. Small, continuous, sub-fusoid, guttulate, broadest slightly below the middle, with the apex pointed and the base terminated by a minute stalk-like protuberance less than 1μ long. Epispore at first smooth becoming fluted, usually with about fifteen ridges arranged longitudinally and often somewhat spirally. At first sub-hyaline, when mature smoky olive brown, $7 \times 2.5-12 \times 3.5\mu$, average $9.6 \times 3\mu$.

Hab. Clay soil. New Zealand.

The author wishes to thank the Director of the Imperial Mycological Institute for access to material in the herbarium and especially Mr E. W. Mason for his unfailing interest and helpful criticism; he is also greatly indebted to Miss E. M. Wakefield for the Latin diagnoses of the new species.

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 PRESTON, N. C. (1943). Observations on the Genus *Myrothecium* Tode. I. The three classic species. *Trans. Brit. myc. Soc.* xxvi, 158-68.

EXPLANATION OF PLATES

PLATE XV

- Fig. 1. *Myrothecium gramineum* Lib. ex Herb. R. B. G. Kew. Spores, $\times 1000$.
 Fig. 2. *M. gramineum* Lib. (Deighton M. 1743) ex Herb. I. M. I. Spores, $\times 1000$.
 Fig. 3. *M. Jollymannii* n.sp. Sporodochia on agar, showing fringing setae, $\times 32$.
 Fig. 4. *M. Jollymannii* n.sp. Fragment of sporodochium with setae, $\times 400$.

PLATE XVI

- Fig. 5. *M. Jollymannii* n.sp. Conidiophores, $\times 1000$.
 Fig. 6. *M. striatisporum* n.sp. Small sporodochia showing fringing hyphae, $\times 60$ approx.
 Fig. 7. *M. striatisporum* n.sp. Spores, $\times 1000$.
 Fig. 8. *M. striatisporum* n.sp. Spores, showing striations, $\times 3000$ approx.

(Accepted for publication 26 May 1947)



Fig. 1



Fig. 2

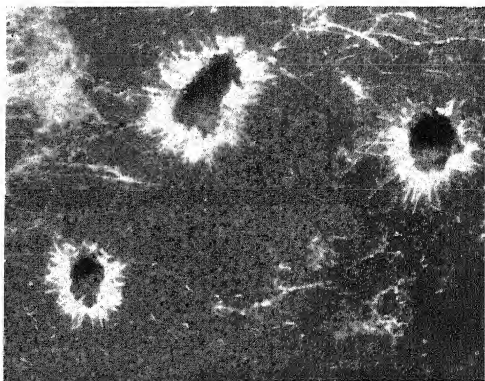


Fig. 3

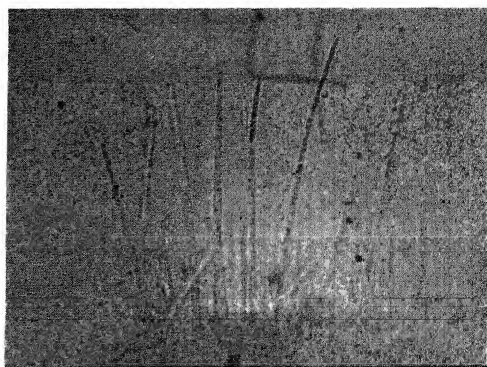


Fig. 4

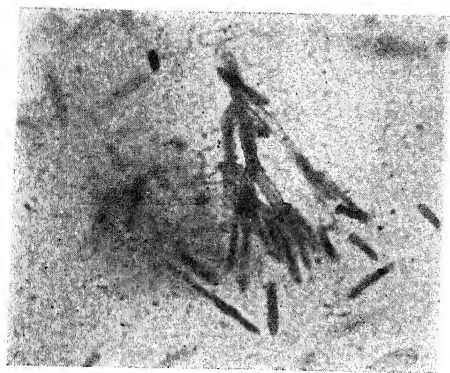


Fig. 5



Fig. 7

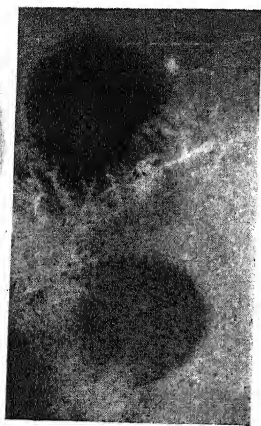


Fig. 6



Fig. 8

THE WATER-RELATIONS OF SPORE DISCHARGE IN *EPICHLÖE*

By C. T. INGOLD, *Birkbeck College, University of London*

(With 2 Text-figures)

To a perithecium from which spores are being actively discharged there must presumably be a steady supply of water making good the loss by evaporation so that the turgidity of the ripening asci may be maintained. Probably most of the lignicolous stromatal Pyrenomycetes (e.g. *Nectria* spp., *Diatrype* spp., *Endothia* spp. and *Hypoxyton* spp.) depend directly on rain for this water supply and spore discharge is limited to periods during or immediately after rain when the fungal tissue is temporarily turgid. *Daldinia concentrica* (see Ingold, 1946) is exceptional in being able to discharge spores during prolonged dry periods by virtue of the considerable reserve of water in the stromatal tissue.

Epichloe typhina (Fr.) Fr., the choke of grasses, causes a systemic infection of its host and eventually produces its perithecial stroma, during July and August, as a crust around the unexpanded leaves immediately above a node of the stem. The innermost hyphae of the stromatal tissue are in intimate association with the living cells of the host. The experiments reported in this paper were designed to answer the following question: does the fungus during periods of active discharge obtain its water from the host cells and, therefore, indirectly from the transpiration stream of the grass, or is discharge limited to damp periods when the stroma is directly wetted by rain or dew?

The specimens used were collected at Sevenoaks, Kent. The form of the fungus on *Dactylis glomerata* was finally selected for use because in the material available the long thread-like ascospores showed no tendency to break up into part-spores and the units in the spore deposit were $190 \times 2\mu$. On the other hand, from specimens of the fungus on *Holcus mollis* the units measured $57 \times 2\mu$ no doubt due to the breaking up of the ascospores into shorter part-spores. The process appears to be carried still further in the form on *Agrostis tenuis* since the spore deposit from this strain was composed of units $32 \times 2\mu$. Each measurement of length is the average of 100 units of the spore deposit chosen at random. It would be interesting to know if these differences obtain in other localities and if the forms on other grasses show still further variations.

Each diseased shoot of *Dactylis* used for an experiment consisted of a length of stem, above this a stroma of *Epichloe*, and above this again a single green leaf (Fig. 1). Each shoot was severed from the plant by a cut made below water to avoid the interruption of the transpiration stream by air blocks in the vessels. With their cut ends in water the shoots were brought indoors for study.

It was found that from the fungus on such shoots, freely exposed to the dry air of a room in summer, spore discharge continued for several days so long as the cut ends of the shoots remained in water.

Discharge can clearly be seen by the naked eye if, when the sun is shining brightly, the fungus is held more or less between the observer and the sun, but in such a way that the stroma can be viewed against a dark background. Then the individual spores, each about a fifth of a millimetre long, can be seen as needle-like motes in the sunbeam. They first come into view about half a millimetre away from the stroma and then are slowly carried away by gentle air currents. If discharge is very vigorous, there are so many spores in the air around the stroma at any instant that it is impossible to observe discharge from a single ascus, but if spores are not being liberated in too great numbers, the successive discharge of the eight spores from an ascus, which is completed in much less than a second, can be seen. The eight discharged spores, maintaining roughly their formation like a squadron of minute aeroplanes, can often be followed for a few centimetres as they drift away.

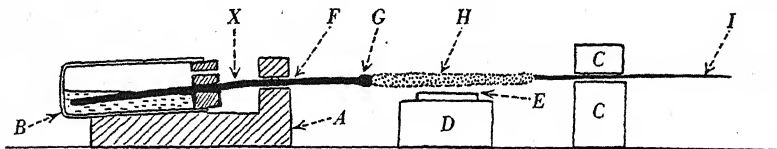
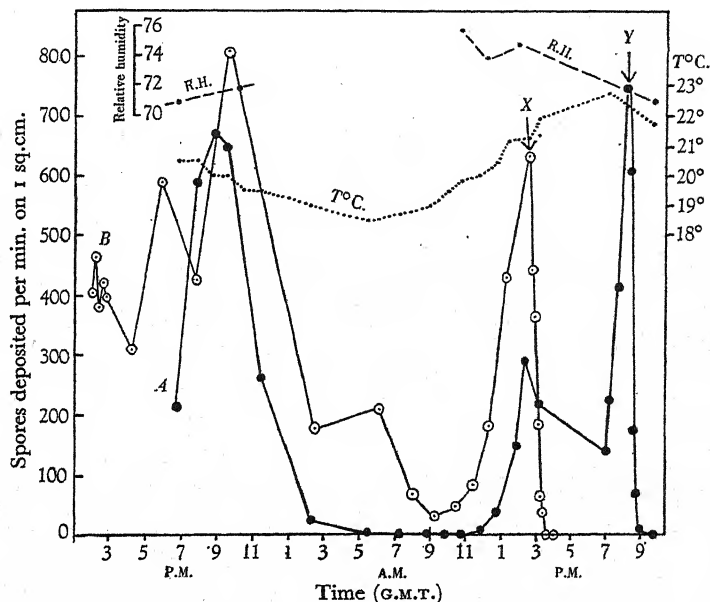


Fig. 1. Method of measuring rate of spore discharge from stroma of *Epichloe*. A, cork support; B, specimen tube; C, glass blocks; D, wooden block; E, glass slide; F, stem of grass; G, node of grass; H, stroma of *Epichloe*; I, leaf of grass.

In studying the rate of spore discharge the arrangement shown in Fig. 1 was used. The cut end of the shoot dipped into water in a specimen tube clamped by a rubber band in a more or less horizontal position to a special cork support (A) consisting of a horizontal and a vertical limb. The stem of the shoot passed through a hole in the vertical limb and through another hole in the cork of the specimen tube (B). In both holes the shoot was wedged firmly with dry cotton-wool. The free leaf of the shoot was held securely in position between two blocks of glass (C). The stroma in this way occupied a horizontal position and below it a wooden block (D) was placed. For observing the rate of spore discharge a microscope slide (E) was used with a square centimetre, sub-divided into square millimetres, etched upon its upper surface. This could quickly be slipped into position under the fungus and it was so arranged that at each observation the etched square occupied exactly the same position relative to the stroma. After a brief exposure (usually fifteen or thirty seconds) the slide was removed and the spores deposited on the square counted under the low power of the microscope. These short exposures were necessary, since it is difficult to count the spores if there are too many, and a single stroma when most active may discharge 2000–10,000 spores a minute. The apparatus was not covered, but was freely exposed to the air of the room, the door and windows

being closed to avoid draughts. The limitations and errors of the method are obvious, but it can be used to give a reasonably accurate measure of changes in the rate of spore discharge. The effect on discharge of interrupting the transpiration stream was studied by cutting the stem with a razor at the point marked X (Fig. 1).

Using the method described above, certain facts were clearly demonstrated. In the first place, there tends to be a daily periodicity of discharge with the minimum in the morning and a maximum in the afternoon or evening. This was observed in nearly all the specimens studied. Secondly, considerable fluctuations in the rate of discharge occur over short intervals



SUMMARY

Spore discharge from *Epichloe typhina* can be observed with the unaided eye.

A method is described for studying the rate of spore liberation.

Discharge tends to be periodic with a minimum in the morning and a maximum in the late afternoon or evening.

In fairly dry air spore discharge continues for several days provided that the water supply to the host tissue is maintained, but when the transpiration stream is stopped by severing the stem, discharge soon ceases.

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(Accepted for publication 3 May 1947)

SLIDE-TRAPS FOR SOIL FUNGI

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(With 1 Text-figure)

The chief problem which confronts the student of soil fungi is the discrimination between fungi which are present in the soil as normal active inhabitants and those which occur there as accidental inactive inhabitants. While the agents responsible for their introduction and distribution in the soil are to some extent the same, for example, percolating water and organisms of various kinds (earthworms, eelworms, insects, etc.) their ultimate behaviour is different in so far as the former grow and reproduce in the soil, while the latter die or remain dormant in the state in which they were originally introduced as spores or pieces of mycelium.

Waksman (1932), whose immense amount of work on soil organisms is well known to workers in this field, advocates two methods of obtaining fungi from soil—the direct and indirect methods. The direct method which consists in incubating for 24 hr. particles of soil on a nutritive agar, is claimed by him to have the advantage that growth from already active mycelium is obtainable within this period. He points out, however, that on account of the different rates at which various fungi grow, only the faster-growing species may be collected in this way. His indirect method is selective only in so far as various media are used in the plating out of the soil dilutions. It does not eliminate the accidental contingent of the soil fungus population.

Blair (1945) briefly reviewed the various techniques used for soil fungus studies and their applications up to 1945. The majority of those which he mentioned were either some modification of the soil-suspension method or of the contact-slide method. He himself used for growth studies of *Rhizoctonia* mycelium in the soil, what he termed a modification of the Rossi-Cholodny slide technique. Before immersing the microscope slides in soil he inoculated them with portions of cultures of *Rhizoctonia*, and subsequently estimated the growth of mycelium over the slide after fixation and staining. While the slide method is adaptable for the purpose of estimating mycelium quantitatively it is, however, only of limited value for qualitative work.

As far as I am aware, Chesters (1940) was the first to devise an apparatus (immersion tube) which contained culture medium and which could be immersed in the soil for the purpose of obtaining fungi actively growing there. This method enabled him to isolate and grow the fungi so obtained. Unfortunately, at least for the average worker, the apparatus is difficult to construct.

Recently, in studies on fungi growing in the casing soil of mushroom beds and in the underlying compost, as well as in soil incubated in beakers, I have obtained satisfactory results with a very simple device. It consists of two standard hanging-drop slides which are clipped together so that their concavities lie opposite each other. Enclosed between the concavities is a small quantity of suitable agar medium (Fig. 1 *a*, *b*). A culture chamber is thus provided to which fungi can gain access by growing in between the slides from the surrounding soil. The moisture of condensation which collects in drops between the slides while the latter are immersed in the soil enables growth to take place until the agar is reached.

Among the fungi which so far have been collected by this method are species of *Alternaria*, *Botryotrichum*, *Cylindrocarpon*, *Fusarium* and *Trichoderma*.

Although the potentialities and adaptability of this device have not yet been fully explored, the author is sufficiently persuaded of its usefulness to recommend it to those engaged in work on soil fungi.

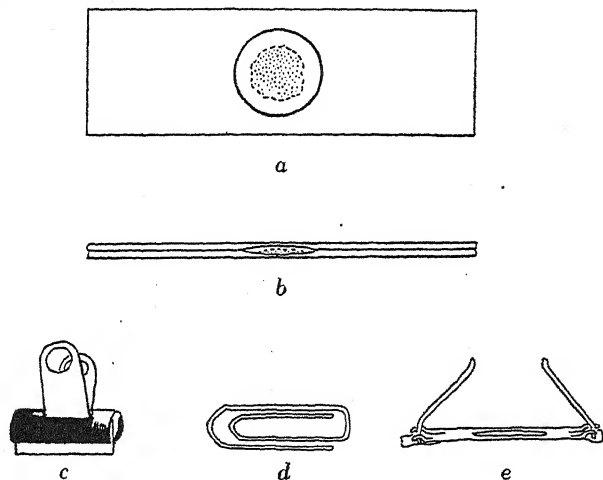


Fig. 1.

PREPARATION AND USE OF SLIDE-TRAPS

The laboratory bench is swabbed with alcohol where the slide-traps are to be prepared.

Hanging-drop slides are cleaned and matched in pairs so that their concavities lie in apposition. They are separated and laid on the bench in two parallel rows proximal and distal to the operator, and a sterile Petri dish lid is laid base upwards on the bench between the individuals of each pair.

The slides in the proximal row are, successively, dipped in alcohol, flamed, and placed concavity upwards, one under each Petri dish lid.

A small quantity of sterile melted agar medium, e.g. soil extract agar such as that used by Ellis (1940), is quickly pipetted into the concavity of

each of the slides under the Petri dish lids. When the agar has solidified, the counterparts from the other row of slides are sterilized as already described, and each is then inverted over its fellow so that the agar is enclosed between the two concavities.

The slides may be secured together by means of various types of clip, as illustrated (Fig. 1c, d, e), or simply with antiseptic plasticine.

When collections are made in mushroom beds, the surface soil for a depth of $\frac{1}{4}$ in. is scraped away with a sterile knife. The slide-traps are flamed quickly and pushed edgewise into the soil vertically or horizontally until completely buried. The surface soil is then replaced. When collections are made in casing soil in beakers, a layer of several inches of soil is first put into the beakers, the traps are partly immersed in this, and are then covered over completely with more soil: this is done with every possible precaution to avoid contamination.

After a suitable period of immersion, usually a week in soil incubated in beakers at 22° C., and a fortnight to 3 weeks in the mushroom beds (where lower temperatures prevail) the traps are lifted and examined under the microscope. Hyphae will usually have grown in between the slides across their width, and may be traced from the edge of the slides right into the agar. If the agar has not been reached by the hyphae the traps may be incubated in a moist chamber until growth is well established in the agar. When the agar has become invaded by mycelium, the slides are prised open and the agar is removed quickly with the sterile flattened tip of a nichrome wire and placed on sterile agar medium such as 3 % malt extract agar in a Petri dish. When the agar is invaded from two opposite sides it may first be cut in half with a micro-scalpel and the two halves then removed separately. The removal of the agar from the traps is carried out preferably in a sterile glass-fronted chamber which admits only the arms for the purpose of manipulation. Isolations may be made subsequently at leisure from the Petri dish transfer.

The advantages of the above method in my opinion are as follows:

- (1) It requires a minimum of apparatus and technique.
- (2) The amount of agar medium used in the slide-traps is infinitesimal.
- (3) A large number of slide-traps may be set up quickly for use in a small area or volume of soil.
- (4) The vegetative and often even reproductive structures, may be studied in situ without disturbance.
- (5) Contamination by bacteria is usually avoided.
- (6) If the slides composing the trap are kept tightly apposed, marauding organisms, capable of carrying spores and bacteria, are kept out.
- (7) Isolates may be made easily by transferring the whole or part of the agar to media in Petri dishes.

The disadvantages are:

- (1) If several different kinds of mould grow into the same small volume of agar some may be suppressed and lost owing to competition.
- (2) Flooding of the surrounding soil may result in water penetrating between the slides by capillary attraction and contaminating the agar with bacteria or mould spores held in suspension.

The author wishes to acknowledge with thanks the permission of the Director of Research and the Directors of the Mushroom Research Association to publish this article.

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(Accepted for publication 28 April 1947)

PERITHECIAL DEVELOPMENT OF *VENTURIA* *INAEQUALIS* ON SCABBED APPLES

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University College, Dublin*

In the autumn of 1946 Apple Scab was severe in the orchard at Glasnevin, Dublin, and the fruit on four large trees of the variety Annie Elizabeth was so badly diseased that it was never picked. This fruit remained hanging on the trees throughout winter until the last week in January 1947, when with the onset of severe wintry weather it was attacked by birds and every apple was knocked down into the grass underneath. Here, a heavy fall of snow protected the fruit from being completely devoured. The snow remained throughout February and part of March, and after its disappearance it was found that while many of the fallen apples had been reduced to mere skins, by slugs and birds, others still retained their shape more or less. Examination of the old skins and particularly of the shrunken fruit on 25 March 1947 showed a fairly prolific development of perithecia of the scab fungus *Venturia inaequalis*. The majority of the asci and ascospores were only in the process of formation at this time, but some were fully mature. Perithecia on the fruit are not so obvious as those occurring on dead leaves, but they can be readily identified with the aid of a pocket lens or binocular microscope in the laboratory.

The literature on Apple Scab is voluminous, and numerous observers in both hemispheres have found perithecia of *Venturia inaequalis* on dead overwintered leaves, but apparently there is no previous record of perithecial development on scabbed fruit.

(Accepted for publication 28 April 1947)

A REVISED LIST OF BRITISH ENTOMOGENOUS FUNGI

By T. PETCH

A list of the entomogenous fungi of Great Britain was published in *Trans. Brit. myc. Soc.* xvii (1932), 170-8. Since then a number of additions have been made, largely through the investigations of Mr E. A. Ellis, on the Broads in the neighbourhood of Norwich, which have yielded several species, new or new to Britain. The value of the new records has been enhanced by many identifications of the host insects, some of which have been kindly furnished to Mr Ellis by Captain N. D. Riley, of the British Museum (Natural History). To them, and to the numerous correspondents who have sent me specimens, I tender my most sincere thanks.

The localities given in the previous list are not repeated, except where only one or two occurrences are known. Some apology is needed for the inclusion of so many records, but they serve to indicate the range and frequency of the species and any variation in hosts. Where a species is said to be common, only records of special interest are included. Names marked with an asterisk are additions to the previous list.

ENTOMOPHTHORACEAE

Empusa Muscae Cohn, in *Nova Acta Acad. Caes. Leopold.-Carol. Germanicae Nat. cur.* xxv (1855), Abh. 1, 301.

On flies. Generally distributed, and common out-of-doors in the summer, usually on grasses. Frequent in gardens on *Asparagus* beds. On a *Capsid* (*Lygus pabulinus*), Cambridge, 19 August 1933 (F. T. Brooks).

Empusa Culicis A. Braun, *Algarm unicell. gen. nov.* (1855), p. 105.

On gnats. Hornsea, 16 July 1931. On small fly, Holt House Wood, King's Lynn, 17 August 1931.

Empusa Aulicae Reichardt in litt. (cf. Bail in *Schrift. d. naturf. Gesellsch. zu Danzig*, n.f., II (1869), 3).

On caterpillars. On grass, North Wootton, 16 October 1933. On lettuce, North Wootton, 22 September 1939. On *Brassica*, North Wootton, 16 October 1941.

Empusa Tipulae (Fres.) Petch, in *Trans. Brit. myc. Soc.* xvii (1932), 170; *Entomophthora Tipulae* Fres., in *Abhandl. d. Senckenberg. naturf. Gesellsch.* II (1858), 206.

On a Tipulid, Aldborough, E. Yorks., 12 September 1933; resting spores in the abdomen, spherical, smooth, hyaline or pale yellow, 32-45 μ diameter, wall up to 4 μ thick. Studland, Dorset, October 1936 (E. W. Jones).

Empusa Fresenii Nowak., in *Proc. Krakow Acad. Sci.* (1883), p. 153.

On aphid (*Macrosiphum taraxaci* Kalt.) on dandelion, Hapton, Lancs., 6 September 1925 (H. Britten).

Empusa Planchoniana (Cornu) Petch, in *Trans. Brit. myc. Soc.* xxi (1937), 36; *Entomophthora Planchoniana* Cornu, in *Bull. Soc. Bot. France*, xx (1873), 189; *Entomophthora ferruginea* Phillips, in *Ann. Mag. Nat. Hist.*, Ser. 5, xviii (1886), 4; non *Empusa Planchoniana* Thaxt., *Entomophthorae U.S.* (1888), p. 165.

On aphids. On greengage, North Wootton, 30 May 1935. Deepdale, Barnard Castle, September 1933. On *Pentatrichopus fragariae* Theob. on strawberry, Glan Conway, 7 June 1943 (Dr C. A. Wood).

**Empusa Thaxteriana* Petch, in *Trans. Brit. myc. Soc.* xxi (1937), 36; *Empusa Planchoniana* Thaxt., *Entomophthorae U.S.* (1888), p. 165.

The entries in the previous list under *Empusa Planchoniana* (Cornu) Thaxt. should be referred to this species.

On aphids on *Prunus Padus*, Deepdale, Barnard Castle, September 1933. On Homopteron (*Philaenus leucophthalmus*), Upton Broad, 20 July 1942, Wheatfen Broad, 13 August 1942 (E. A. Ellis).

Empusa papillata Thaxt., *Entomophthorae U.S.* (1888), p. 166.

On flies (*Sciara* sp.) on *Lactarius*, Allerthorpe Common, E. Yorks., 2 August 1936.

**Empusa apiculata* Thaxt., *Entomophthorae U.S.* (1888), p. 163.

On flies and a leaf-hopper, Heatree, Dartmoor, 24 September 1935.

**Empusa Tenthredinis* (Fres.) Thaxt., *Entomophthorae U.S.* (1888), p. 162; *Entomophthora Tenthredinis* Fres., in *Abhandl. d. Senckenberg. naturf. Gesellsch.* II (1858), 205.

On larvae of sawflies on *Spiraea Ulmaria*, Parish Marsh, Wheatfen Broad, 14 and 27 June 1943 (E. A. Ellis).

**Empusa Grylli* (Fres.) Nowak., in *Proc. Krakow Acad. Sci.* (1883), p. 168; *Entomophthora Grylli* Fres., in *Bot. Zeitung*, xiv (1856), 882.

On a grasshopper, Allerthorpe Common, E. Yorks., 2 August 1936.

**Empusa Acaridis* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 87.

On a mite (*Pergamasus crassipes* Linn.), Home Marsh, Wheatfen Broad, 9 August 1942 (E. A. Ellis).

**Empusa Forficulae* (Giard) Petch var. *major* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 87.

On earwigs, Old Lakenham, 10 August 1942 (E. A. Ellis).

Entomophthora sphaerosperma Fres., in *Bot. Zeitung*, xiv (1856), 882.

Common. Usually on aphids and flies.

On Ichneumonidae, Deepdale, Barnard Castle, September 1933; Beckdale near Helmsley, 3 September 1935; Millington, E. Yorks., August 1936, September 1937. On an ant, Duncombe Park, Helmsley, 2 September 1935. On Hemiptera on nettles, Haye Park, Ludlow, September 1937. On nymph of Heteropteron, Upton Broad, 20 July 1942 (E. A. Ellis). On nymph of Homopteron, Parish Marsh, Wheatfen Broad, 14 June 1943 (E. A. Ellis). Epidemic on larvae of *Pieris brassicae*, Adisham, Kent, 5 September 1945 (S. G. Jary).

The record in the previous list, on beetle, Hornsea, 14 July 1931, was incorrect.

Entomophthora Aphidis Hoffm., in Fres. in *Abhandl. d. Senckenberg. naturf. Gesellsch.* II (1858), 208.

On aphids. Common. On root aphid of lettuce (*Pemphigus lactucarius*), September 1937 (N. C. Preston), with resting spores (see *Trans. Brit. myc. Soc.* xxiii (1939), 128).

**Entomophthora occidentalis* Thaxt., *Entomophthorae U.S.* (1888), p. 171.

On aphids. On sycamore, Millington Wood, near Pocklington, Yorks., 4 September 1937. On *Ranunculus repens*, Old Lakenham Marshes, 26 July 1942 (E. A. Ellis).

**Entomophthora Aphrophorae* Rostrup, in *Botan. Tidskr.* xx (1896), 128; Petch in *Trans. Brit. myc. Soc.* xix (1935), 179.

On Homoptera, usually *Philaenus spumarius* (*Aphrophora spumaria* L.).

Arncliffe Woods, near Whitby, August 1930. Grassington, September 1931. Aldborough, E. Yorks., September 1933 and August 1937. Hedon, E. Yorks., September 1933 and August 1937. Lartington and Deepdale, N.W. Yorks., September 1933. Dipton Wood near Corbridge, September 1933. Beckdale near Helmsley, September 1935. Pallathorpe, Bolton Percy, July 1937 (W. G. Bramley). Millington Wood near Pocklington, September 1937. The Sneap, Co. Durham, October 1937 (A. W. Bartlett). Fritton Bog, Suffolk, September 1933 (E. A. Ellis). On *Athysanus griseus* Zett., Alderfen Broad, Norfolk, July 1935 (E. A. Ellis). Poor's Marsh, Wheatfen Broad, September 1942 (E. A. Ellis). On *Philaenus leucophthalmus*, Tas Marshes, Thurston, and Upton Broad, July 1942 (E. A. Ellis). Wychwood Forest near Oxford, August 1940 (E. W. Jones).

Entomophthora muscivora Schroet., in *Krypt.-Flora v. Schlesien*, III (1886), pt. 1, 223.

On flies. On ivy, Aldborough, E. Yorks., 30 September 1932. Baldersdale, N.W. Yorks., 18 September 1933. Allerthorpe, 3 August 1936. Hubberholme, 8 September 1936. Little Budworth near Tarpoley, Cheshire, 11 September 1938 (F. B. Stubbs). Newport, Salop, 15 October 1945 (N. G. Preston). Wytham, Berks., 9 October 1946 (Prof. G. D. H. Carpenter).

Entomophthora americana Thaxt., *Entomophthorae* U.S. (1888), p. 179.

On flies. Eavestone Woods, Ripon, August 1933 (Miss L. M. Anderson). Baldersdale, N.W. Yorks., 18 September 1933. Deepdale, N.W. Yorks., 19 September 1933. Newcastle, October 1935 (A. W. Bartlett). Doncaster, September 1936 (Mrs Morehouse). Hubberholme, 8 September 1936. Park Wood, Elland, 15 July 1937 (E. Dearing). Plymouth, September 1942 (per Dr C. B. Williams). Godstow Osier Holt near Oxford, June 1945 (E. W. Jones).

The record of this species on a leaf-hopper in the previous list is an error.

Entomophthora variabilis Thaxt., *Entomophthorae* U.S. (1888), p. 183.

On flies. Lartington, 16 September 1933, resting spores pale brown, spherical, smooth, 30–40 μ diameter. Beckdale near Helmsley, 3 September 1935. Allerthorpe, 2 August 1936. Buckden, September 1936.

Entomophthora dipterigena Thaxt., *Entomophthorae* U.S. (1888), p. 177.

On flies. Common. Helmside Ghyll, Dent, 5 June 1933 (F. A. Mason), resting spores external, hyaline, spherical, thick-walled, smooth, 26–33 μ diameter. Lartington, 16 September 1933. Dovedale, Derbyshire, 1 June 1935. Duncombe Park, Helmsley, 1 September 1935, resting spores 27–40 μ diameter. Heatree, Dartmoor, 24 September 1935. Allerthorpe Common and Millington Wood, August 1936. Buckden, September 1936. North Wootton, 24 September 1936. On *Calliphora vomitoria*, Norwich, 13 September 1936 (E. A. Ellis). Haye Park, Ludlow, 21 September 1937. Boyne Park, Ludlow, 23 September 1937. On *Psychodidae*, Wheatfen Broad, 7 July 1941 and 27 June 1943 (E. A. Ellis).

Entomophthora echinospora Thaxt., *Entomophthorae* U.S. (1888), p. 180.

On flies. Lartington, 16 September 1933. Buckden, 5 September 1936. Millington Wood, 4 September 1937. Buttercrambe Moor Wood, 6 September 1937. Boyne Park, 23 September 1937. Dartington, 25 September 1935. Burntfen Broad, 25 September 1941 (E. A. Ellis). Wheatfen Broad, 13 August 1942 (E. A. Ellis). North Wootton, 22 August 1942, mass of resting spores bright coral red, not yellow.

[*Entomophthora Lampyridarum* Thaxt., *Entomophthorae* U.S. (1888), p. 169. The record of this species in the previous list is an error.]

Entomophthora coleopterorum Petch, in *Trans. Brit. myc. Soc.* xvii (1932), 172, and xxvii (1944), 88.

On beetles. Lartington, Yorks., 16 September 1933. On *Sitones flavescens*, Wick, 10 October 1937 (Miss D. J. Jackson).

**Entomophthora anglica* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 89.

On beetles. On *Cantharis*, Hornsea, 14 July 1931. On *Agriotes sputator*, Coton, Cambs., 3 May 1931 and June 1933 (E. W. Jones). On *Cantharis*, Pickering, 6 June 1938 (W. G. Bramley). On *Lochmaea suturalis*, Edinburgh,

June 1939 (R. W. G. Dennis). On *Cantharis* sp., Old Lakenham, 25 June 1942 (E. A. Ellis). On a Staphylinid, Wheatfen Broad, 9 August 1942 (E. A. Ellis). On larvae of *Galerucella tenella*, Wheatfen Broad, 14 June 1943 (E. A. Ellis). Roydon Common, Norfolk, May 1945 (C. P. Petch).

**Entomophthora virescens* Thaxt., *Entomophthorae* U.S. (1888), p. 178.

On a caterpillar on *Brassica*, North Wootton, 30 September 1942.

Entomophthora (*Tarichium*) *Richteri* (Bres. & Star.) Bubák, in *Ann. Myc.* xiv (1916), 341; *Massospora Richteri* Bres. & Staritz, in *Hedwigia* (1892), p. 133; *Tarichium Richteri* (Bres. & Star.) Lakon, in *Zeitsch. f. PflanzenKr.* xxv (1915), 257; *Entomophthora Lauxaniae* Bubák, in *Hedwigia* (1903), p. (100.)

In flies. Recorded in the previous list as *Entomophthora Lauxaniae*. Rokeby, 17 September 1933. Baldersdale, 18 September 1933. Deepdale, N.W. Yorks., 19 September 1933. Austwick, Yorks., 18 September 1934. Buckden, September 1936.

Entomophthora (*Tarichium*) *atrosperma* Petch, in *Trans. Brit. myc. Soc.* xvii (1932), 172.

On aphid. Grassington, 12 September 1931 (F. A. Mason).

**Tarichium megaspermum* Cohn, in *Beitr. z. Biol. d. Pflanzen* 1 (1875), 58.

In larvae of *Plusia gamma* on *Pisum*, Romney Marsh, Kent, July 1946 (S. G. Jary).

CHYTRIDIACEAE

**Myrophagus ucrainicus* (Wize) Sparrow, in *Mycologia*, xxxi (1939), 443; *Olpidiopsis ucrainica* Wize, in *Akad. Umiej. Krakow (Bull. Intern. Cl. Sci. Math. nat.)* (1904), 715; *Entomophthora reticulata* Petch, in *Trans. Brit. myc. Soc.* xxiii (1939), 127; *Naturalist* (March 1940), p. 68.

In a dipterous pupa, Ingleborough, September 1934.

HYPOCREACEAE

**Torrubiella aranica* Boud., in *Rev. Myc.* vii (1885), 227.

On large spiders under hanging moss on a cliff face, Hubberholme, Yorks., 8 September 1936; on spider, Wheatfen Broad, 2 August 1945 (E. A. Ellis).

**Torrubiella albolanata* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 85.

On spiders among *Cladium*, etc., usually *Gongylidium rufipes*, Wheatfen Broad, 21 June 1942, 9 and 13 August 1942, 14 June 1943 (E. A. Ellis). On spider's egg cocoon, Wheatfen Broad, 15 April 1945 (E. A. Ellis).

Conidial stage—*Cylindrophora araneorum* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 85, with the perithecial stage or separately.

**Torrubiella albotomentosa* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 86.

On a dipterous pupa in a dead stem of *Glyceria maxima*, Parish Marsh,

Wheatfen Broad, 20 May 1943 (E. A. Ellis). On dipterous pupae, Wheatfen Broad, 17 May 1945 (E. A. Ellis).

Cordyceps militaris (L.) Link, *Handb.* III (1833), 347.

On lepidopterous larvae and pupae. Generally distributed. On larvae of *Hepialus*, Austwick, 18 September 1934.

The conidial stage of this species is not *Spicaria* (*Isaria*) *farinosa*, but a *Cephalosporium* (see Petch, *Cordyceps militaris* and *Isaria farinosa*, in *Trans. Brit. myc. Soc.* XX (1936), 216-24). This has been named *Cephalosporium militare* by Kobayasi in *The Genus Cordyceps and its Allies* (1941), p. 113.

Cordyceps gracilis Mont. & Dur., *Flor. Alger.* I (1846-9), 449.

On larvae of Lepidoptera, usually *Hepialus*. Ludlow, 28 May 1932. Whitcliffe Woods, Richmond, Yorks., 24 April 1937 (J. B. Nicholson). Ponterwyd near Aberystwyth, 2 May 1940 (S. J. Hughes). Long Crendon, Oxon., March 1945 (J. Howard Brown).

Conidial stage—*Isaria dubia* Delacroix.

Cordyceps entomorrhiza (Dicks.) Link, *Handb.* III (1833), 347.

On a beetle larva, Bulstrode, Bucks., in the autumn (Dickson, ante 1785). No further records. The records for N.E. and N.W. Yorks. in Mason and Grainger, *Catalogue of Yorkshire Fungi*, p. 33, were not in the MSS. submitted to me, and doubtless refer to *Cordyceps gracilis*.

Conidial stage—probably *Hirsutella eleutheratorum* (Nees) Petch, but until the perithecial stage is available, that cannot be ascertained.

**Cordyceps tuberculata* (Lebert) Maire, in *Bull. Soc. d'Hist. nat. d. l'Afrique du Nord*, VIII (1917), 165; *Acrophyton tuberculatum* Lebert, in *Zeitschr. f. wiss. Zool.* IX (1858), 448; *Torrubia Sphingum* (Schw.) Tul., *Sel. Fung. Carp.* III (1865), 12; *Cordyceps Sphingum* (Schw.) B. & C., *Fungi Cubenses*, no. 746 (1869).

On larvae, pupae and imagoes of Lepidoptera. On a pupa in moss under nettles, Alderfen Broad, Norfolk, 15 August 1940 (E. A. Ellis). On a pupa under alders, Low Common, Hellington near Norwich, 9 May 1943, with the conidial stage, *Akanthomyces Sphingum* (Schw.) Petch, on the same pupa (E. A. Ellis). On lepidopterous pupae, Alderfen Broad, 19 August 1945, Strumpshaw Marsh, 10 October 1943, Brundall Marshes, 16 August 1945 (all coll. E. A. Ellis).

Previous records of *Cordyceps Sphingum* in Britain have been based on Berkeley and Broome's record of the conidial stage, as *Isaria Sphingum* Schw., on pupae of Diptera, Kincardineshire in *Notices of British Fungi*, no. 1710. That specimen, however, is a linear form of *Spicaria* (*Isaria*) *farinosa*.

Cordyceps sphecocephala (Kl.) Cooke, *Vegetable Wasps*, etc. (1892), p. 40.

On Hymenoptera. The Wood, Wheatfen Broad, 20 September 1942, found unattached among dead leaves (E. A. Ellis).

Conidial stage—*Hymenostilbe sphecophila* (Ditm.) Petch.

Cordyceps Forquignonii Quélet, in *Assoc. Franc. p. l'Avancement d. Sciences* (1887), p. 6.

On flies. Auchincruive, Ayrshire, 1934 (R. W. G. Dennis). On an Anthomyid, *Cyrtonura estabulans* Fln., The Wood, Wheatfen Broad, 26 March 1942 (E. A. Ellis). Spreacombe, Braunton, North Devon, September 1945, July 1946 (F. R. Elliston Wright).

Conidial stage—*Hymenostilbe muscaria* Petch.

Cordyceps clavulata (Schw.) E. & E., *North American Pyreno* (1892), p. 61; *Cordyceps pistillariaeformis* B. & Br., in *Ann. Mag. Nat. Hist. Ser. 3*, VII (1861), 451.

On scale insects, *Lecanium* spp. On a scale insect on wych elm, Batheaston, Somerset, March 1860, October 1860 (Broome). No further records.

Conidial stage—*Hirsutella lecaniicola* (Jaap) Petch.

MYRIANGIACEAE

Myriangium Duriaei Mont. & Berk., in *Hooker's London Journ. Bot.* IV (1845), 73.

In Britain, usually on *Chionaspis salicis* on ash in the south and west. No further records.

MUCEDINACEAE

**Oospora ovorum* Trabut, in *Rev. gén. Bot.* III (1891), 404.

On cocoons of a Braconid parasite on *Odonestis potatoria*, Wheatfen Broad, 23 September 1945 (E. A. Ellis).

Scopulariopsis penicillioides (Delacr.) A. L. Smith & Ramsbottom, in *Trans. Brit. myc. Soc.* V (1915), 164; *Monilia penicillioides* Delacr., in *Bull. Soc. myc. France*, XIII (1897), 114.

On pupae of the Cinnabar Moth from Farnham Royal, May 1931.

**Acremonium tenuipes* Petch, in *Trans. Brit. myc. Soc.* XXI (1937), 66; *Sporotrichum araneorum* Cav., *Fung. Longob. exsicc.* no. 240 (1892); *Verticillium* sp., Sartory, Sartory & Meyer, in *C.R. Soc. Biol. Paris*, CVII (1931), 53-5.

On spiders and spider egg masses. Reffley Wood near King's Lynn, 8 June 1930. Holt House Wood near King's Lynn, 17 August 1931. The Wood, Wheatfen Broad, 7 March 1943 (E. A. Ellis).

**Acremonium araneorum* Petch, in *Trans. Brit. myc. Soc.* XVI, 242.

On Homopteron, Postwick Marshes, 16 August 1945 (E. A. Ellis).

**Cylindrophora araneorum* Petch, in *Trans. Brit. myc. Soc.* XXVII (1944), 85.

The conidial stage of *Torrubiella albolanata* Petch. On spiders, with the perithecial stage or separately. Wheatfen Broad, 9 August 1942, etc. (E. A. Ellis).

**Cephalosporium* (*Acrostalagmus*) *aphidicola* Petch, in *Trans. Brit. myc. Soc.* xvi (1931), 71.

On aphid (*Capitophorus fragariae*) on strawberry, Auchincruive, Scotland, February 1939 (C. E. Foister).

Cephalosporium (*Acrostalagmus*) *Lefroyi* Horne, in *Gard. Chron.* lvii (1915), 139.

On *Aleyrodes vaporarium*; cf. Petch in *Trans. Brit. myc. Soc.* xxv (1942), 262.

**Cephalosporium* (*Acrostalagmus*) *subclavatum* Petch, in *Trans. Brit. myc. Soc.* xxv (1942), 262.

On lepidopterous larvae. On a Caradrinid larva from a fen locality, May 1941 (J. C. F. Fryer). On larvae of *Nudaria senex* Hb., Home Marsh, Wheatfen Broad, 9 August 1942 and 19 May 1943 (E. A. Ellis).

Cephalosporium (*Acrostalagmus*) *coccorum* Petch, in *Trans. Brit. myc. Soc.* x (1925), 175.

On *Chionaspis*, *Lepidosaphes*, etc. On subterranean coccids, Hagg Wood, Burnsall, 15 September 1931. On mealy bugs, Stratton Strawless, 4 October 1934. On mealy bug on gorse, Totnes, 27 September 1935.

Cephalosporium (*Acrostalagmus*) *Eriophytis* (Masse) Petch, in *Trans. Brit. myc. Soc.* xvi (1931), 66; *Botrytis Eriophyes* Masse, in Taylor, *Journ. econ. Biol.* iv (1909), 5; *Verticillium Eriophytis* (Masse) Sacc. & Trott., *Syll. Fung.* xxii (1913), 1299.

On *Eriophyes ribis* in 'big bud' of black-currant.

Cephalosporium (*Acrostalagmus*) *muscarium* Petch, in *Naturalist* (April 1931), p. 102.

On flies. Deepdale, N.W. Yorks., 19 September 1933; Marsh Cote, Saltaire, 24 October 1933 (W. P. Winter). On *Urophora solstitialis* L., Cambridge, March 1935 (F. T. Brooks). Dartington, 25 September 1935. Cambridge, 31 July 1942 (F. T. Brooks).

On aphids. Bolton Woods, 17 September 1931; Lartington, 16 September 1933; Rokeby, 17 September 1933; Deepdale, 19 September 1933.

On beetles. Deepdale, 19 September 1933; Pallathorpe, 26 August 1935 (W. G. Bramley); on *Plateumaris braccata*, Wheatfen Broad, 9 August 1942 (E. A. Ellis); on a weevil (*Erirrhinus nereis* Pk.), Wheatfen Broad, 4 June 1942 (E. A. Ellis).

On Homoptera. Wheatfen Broad, 25 July 1935 (E. A. Ellis); Old Lakenham Marshes, 26 July 1942 (E. A. Ellis).

On Ichneumon. Wheatfen Broad, 9 August 1942 (E. A. Ellis). On chalcid larva (*Torymus cyanimus*), Cambridge, March 1935 (F. T. Brooks).

On spider cocoon. Hubberholme, 9 September 1936. On spider, Wheatfen Broad, 9 August 1942 (E. A. Ellis).

Cephalosporium (Acrostalagmus) dipterigenum Petch, in *Naturalist* (April 1931), p. 102.

On a beetle (*Cantharis lateralis*), Studland, June 1933 (E. W. Jones). On a spider, Millington Wood near Pocklington, 4 September 1937. On Homoptera, Wheatfen Broad, 5 October 1944 and Old Lakenham Hall, 27 August 1942 (E. A. Ellis).

**Cephalosporium militare* Kobayasi, *The Genus Cordyceps and its Allies* (1941), p. 113.

The conidial stage of *Cordyceps militaris* (L.) Link. At the base of the perithecial clavae of the *Cordyceps*, Austwick, Yorks., 18 September 1934. Also obtained in culture from the ascospores of the *Cordyceps*, cf. Petch, *Cordyceps militaris* and *Isaria farinosa*, in *Trans. Brit. myc. Soc.* xx (1936), 216-24. Kobayasi did not give a description in the publication cited.

Beauveria Bassiana (Bals.) Vuill., in *Bull. Soc. Bot. France*, LIX (1912), 40.

On insects of all kinds, among moss or dead leaves, or under bark or logs, etc. Numerous records, of which the following are noteworthy. On a bee (*Bombus pratorum*), Castle Gardens, Norwich, 2 October 1933 (E. A. Ellis). On spiders, North Wootton, 18 October 1933. On Ichneumon, North Wootton, 18 October 1933. On fly, Pinhole Cave, Derbyshire, 24 March 1934 (F. A. Mason). On *Picromerus bidens*, Camberley, May 1934 (E. E. Green). On *Hepialus* larvae, Harpenden, April 1934 (H. F. Barnes). On leaf-hoppers, Rawcliffe near Goole, 4 August 1934. On a wasp, North Wootton, 1 March 1935. On beetles, Pallathorpe, Bolton Percy, 26 August 1936 (W. G. Bramley). On Homopteron, Upper Hellesdon, 25 August 1940 (E. A. Ellis).

Beauveria densa (Link) Picard, in *Ann. Serv. Epiph.* 1 (1913), 160.

On insects of all kinds, but usually on beetles. On a weevil, Rawcliffe near Goole, 4 August 1934. On beetles (*Strophosomus lateralis*, etc.), Belton Heath, Suffolk, 3 January 1935 (E. A. Ellis). [On cockchafer larvae and adults, Kennington forest nursery near Oxford and Fair Oak nursery near Tintern, 1942 (J. M. B. Brown) see note.] On a caterpillar, Old Lakenham Hall, 2 August 1942 (E. A. Ellis). On a beetle (*Plateumaris braccata*), Wheatfen Broad, 9 August 1942 (E. A. Ellis). On beetles (*Galerucella tenella*), Wheatfen Broad, 25 February 1943 (E. A. Ellis). On a wasp, Wheatfen Broad, 25 February 1943 (E. A. Ellis). On ants, Hellington, 10 June 1943 (E. A. Ellis).

**Beauveria effusa* (Beauv.) Vuill., in *Bull. Soc. Bot. France*, LIX (1912), 40.

On pupa of *Agrotis ripae* (larva from Studland), June 1936 (C. Diver). On indet. insect, Wheatfen Broad, 20 December 1942 (E. A. Ellis). On beetles (*Galerucella tenella*), Wheatfen Broad, 6 May 1943 (E. A. Ellis).

Metarrhizium Anisopliae (Metsch.) Sorok., in *Zeitschr. d. Kais. Landw. Gesellsch. f. Neurussland* (1879), p. 268.

On insects of all kinds. Isolated from a dead wireworm, Cambridge,

October 1939 (R. Leach). On wireworm, Rothamsted, January 1941 (H. C. Gough). On larva of wireworm (*Corymbites cupreus*), Cardiff, 1 September 1942 (S. J. Hughes).

**Cylindrodendrum suffultum* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 91.

On pupae of Diptera. On pupae of *Clytocybus ocellaris* Meig., Trowse Marshes, 7 August 1942; Wheatfen Broad, 9 August 1942, 13 August 1942, 19 June 1942. On Tipulid pupae, Wheatfen Broad, 19 June 1943. On Stratiomyid pupae, Wheatfen Broad, 19 June 1943. On dipterous pupae, St Olave's, Suffolk, 18 July 1944 (all coll. E. A. Ellis).

**Verticillium menisporoides* Petch, n.sp. On spider, St Olave's, Suffolk, 18 July 1944 (E. A. Ellis).

**Spicaria prasina* (Maubl.) Saw., in *Descr. Cat. Formosan Fungi* (1919); *Nomuraea prasina* Maubl., in *Bull. Soc. myc. France*, xix (1903), 295.

On caterpillars. On a caterpillar on grass, Wheatfen Broad, August 1939; Bradeston Hills, 30 September 1945; Cringleford Marshes, 28 October 1945 (all coll. E. A. Ellis).

**Spicaria stricta* Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 89.

On a spider, Wheatfen Broad, 13 August 1942 (E. A. Ellis).

**Spicaria fumoso-rosea* (Wize) Vassil., in *Morbi Plant.*, Leningrad, xviii (1929), 113; *Isaria fumoso-rosea* Wize, in *Bull. Acad. Cracovie* (1905), p. 354; Petch, in *Trans. Brit. myc. Soc.* xxvii (1944), 90.

On larvae of *Lamproyris noctiluca* (glow-worm) in marsh litter. Wheatfen Broad, 12 September 1937, 13 August 1942, 25 August 1942, 27 September 1942, 15 October 1944; Blundeston Marshes, Suffolk, 4 September 1943; Strumpshaw Marsh, Norfolk, 9 October 1944, 12 August 1945; Alderfen Broad, 19 August 1945 (E. A. Ellis). On a lepidopterous pupa, Wheatfen Broad, 4 October 1942 (E. A. Ellis).

Spicaria (Isaria) farinosa (Holms.) Vuill., *Bull. Soc. myc. France*, xxvii (1910), 75-82; *Isaria farinosa* (Holms.) Fr., *Syst. Myc.* iii (1832), 271; *Spicaria (Isaria) Swantonii* (A. L. Smith) Petch, in *Naturalist* (April 1931), p. 103; *Coremium Swantonii* A. L. Smith, in *Trans. Brit. myc. Soc.* xi (1919), 156.

On insects of all kinds, either as an *Isaria* or a simple *Spicaria*.

Aspergillus depauperatus Petch, in *Trans. Brit. myc. Soc.* xvi (1931), 244.

On *Lepidosaphes ulmi* on hawthorn, Hunstanton, February 1921.

STILBACEAE

Isaria dubia Delacr., in *Bull. Soc. myc. France*, ix (1893), 264.

The conidial stage of *Cordyceps gracilis*. Grown in culture from ascospores of *Cordyceps gracilis*, May 1932. On larvae of Swift Moth (*Hepialus*) from Dr Redington, Glos., 9 November 1940.

**Isaria ochracea* Boud., in *Bull. Soc. myc. France*, xix (1903), 197.

On *Sphinx ligustri*, Norwich, 1939.

**Isaria tenuipes* Peck, *Thirty-first Report N.Y. State Museum*, p. 44 (1879).

On lepidopterous pupae. The Wood, Wheatfen Broad, 15 October 1938, 18 August 1940, 18 September 1941, 20 September 1942 (E. A. Ellis).

Hymenostilbe muscaria Petch, in *Naturalist* (April 1931), p. 101.

The conidial stage of *Cordyceps Forquignoni*. On flies. Hubberholme, 9 September 1936. Whitecliffe and Boyne Park, Ludlow, September 1937. On a Cordylurid (*Norellia upinimana* Fln.). Wheatfen Broad, 26 March 1942 (E. A. Ellis). On Anthomyids, Wheatfen Broad, 18 June 1942, 1 October 1942 (E. A. Ellis). Spreacombe, N. Devon, December 1944, 30 August 1945, September 1945 (F. R. Elliston Wright).

On unweathered specimens the conidia measure $7-11 \times 3-4.5 \mu$.

Hymenostilbe arachnophila (Ditm.) Petch, in *Naturalist* (August 1931), p. 249; *Isaria arachnophila* Ditm., in Sturm, *Deutschl. Flora*, Abt. III (1817), Bd. 1, III, Pl. 55.

On spiders, usually attached to living leaves. Hunstanton, July 1932 (T. Harris). Lartington, 16 September 1933. Deepdale, N.W. Yorks., 19 September 1933. Dipton Wood near Corbridge, 21 September 1933. Chopwell Wood, Durham, 22 September 1933. Whitecliffe and Kinlet near Ludlow, September 1937. Old Lakenham, 25 June 1942 (E. A. Ellis). Bradeston Hills, 4 October 1945 (E. A. Ellis).

Prof. E. B. Mains has found a *Cordyceps*, *C. Thaxteri* Mains, in company with *H. arachnophila* in America (*Journ. Elisha Mitchell Sc. Soc.* LV (1939), 120.

**Hymenostilbe sphecophila* (Ditm.) Petch, in *Trans. Brit. myc. Soc.* XXI (1937), 55; *Isaria sphecophila* Ditm., in Sturm, *Deutschl. Flora*, Abt. III (1817), Bd. 1, 155, Pl. 57.

On Hymenoptera. The conidial stage of *Cordyceps sphecocephala*. On Ichneumon, Chopwell Wood, Durham, 22 September 1933. On Ichneumon, Horsey Mere, 5 May 1938 (E. A. Ellis).

In the previous list, mention was made of a probable specimen of *Hymenostilbe sphecophila* figured by Worthington G. Smith in *Gard. Chron.* on a bee, later said to be a wasp. In a more detailed figure in W. G. Smith, *Diseases of Field and Garden Crops* (1884), p. 59, the insect is clearly a wasp.

Akanthomyces Sphingum (Schw.) Petch, in *Trans. Brit. myc. Soc.* XXVII (1944), 82. *Isaria Sphingum* Schw., *Syn. Fung. Carol. Super.* (1822), p. 126; *Akanthomyces aculeata* Lebert, in *Zeitschr. f. wiss. Zool.* IX (1858), 448; *Hymenostilbe Sphingum* (Schw.) Petch, in *Trans. Brit. myc. Soc.* XVI (1932), 217; ? *Isaria floccosa* Fr., *Syst. Myc.* III (1832), 274; ? *Isaria strigosa* Fr., *Syst. Myc.* III (1832), 274.

On lepidopterous pupae, larvae and imago. The conidial stage of *Cordyceps tuberculata*. On a lepidopterous pupa, with the *Cordyceps*, Low Common, Hellington near Norwich, 9 May 1943 (E. A. Ellis).

Gibellula araneorum (Schw.) Syd., Petch in *Naturalist* (August 1931), p. 249; *Isaria araneorum* Schw., *Syn. Fung. Carol. Super.* (1822), p. 126; *Gibellula araneorum* Syd., in *Engler's Bot. Jahrb.* LVII (1922), 321.

On spiders attached to grasses or to the underside of leaves. Bradwell, Suffolk, 18 July 1933. Fritton Bog, Lothingland, 3 September 1933 (E. A. Ellis). Baldersdale, 18 September 1933. Aldeby, E. Norfolk, 7 July 1935 (E. A. Ellis). Wheatfen Broad, 25 July 1935, 5 October 1941, 22 October 1944 (E. A. Ellis). Berry Pomeroy, 26 September 1935. Hubberholme, 8 September 1936. Burntfen Broad, 25 September 1941 (E. A. Ellis). Hellington, 10 June 1943 (E. A. Ellis). On *Gongylidium rufipes*, Wheatfen Broad, 27 June 1943 (E. A. Ellis). Brundall Marshes, 24 August 1945 (E. A. Ellis). On a Homopteron and a small dipterous pupa, Swannington Upgate Common, 30 July 1944 (E. A. Ellis).

Hirsutella Eleutheratorum (Nees) Petch, in *Naturalist* (February 1932), p. 46; *Isaria Eleutheratorum* Nees, *System d. Pilze* (1817), p. 85.

On beetles and beetle larvae. Dunscombe Park, Helmsley, 1 September 1935. Buckden, 7 September 1936. On *Rhizophagus ferrugineus* Pk., Ballater, 18 August 1938, and Glendye, Scotland, 20 August 1938 (H. S. Hanson). On *Paederis riparius*, Wheatfen Broad, 5 October 1941, Hickling Broad, 10 July 1945 (E. A. Ellis). On Staphylinids, Surlingham Broad, 12 July 1944, Postwick Marshes, 18 October 1945, 28 October 1945 (E. A. Ellis). Strumpshaw Broad, 31 August 1944 (E. A. Ellis). Cirencester, February 1944 (— Shaw, per Miss E. M. Wakefield).

**Hirsutella Saussurei* (Cooke) Speare, in *Mycologia*, XII, 69.

On Ichneumonid and small Hymenoptera, Postwick Marshes, 6 May 1945, 18 October 1945, 28 October 1945 (E. A. Ellis). On?, Alderfen Broad, 19 August 1945 (E. A. Ellis).

**Hirsutella citriformis* Speare, in *Mycologia*, XII, 70.

On Homoptera (including *Kelisia scottii* (Fieb.), *Areopus pulchellus* Curt.) and Heteroptera (*Nabis lineatus* Dahlb.), Postwick Marshes, 18 October 1945 (E. A. Ellis).

Hirsutella subulata Petch, in *Naturalist* (February 1932), p. 48.

On caterpillar, Milton, Northants. (J. Henderson, without date, but before 1881), recorded as *Isaria floccosa* Fr. in B. & Br., *Notices of British Fungi*, no. 1096. No further British records, but has been found in America, on the larva of the 'Codling Moth' under a piece of bark, Washington, D.C., and on the larva of *Aegeria pyri* Harris in apple bark, Flatbush, New York; cf. Petch in *Trans. Brit. myc. Soc.* XXI (1937), 57.

**Hirsutella exoleta* (Fr.) Petch, in *Naturalist* (November 1936), p. 251; *Isaria exoleta* Fr., *Syst. Myc.* III (1832), 275; *Cordyceps fuliginosa* Ces., *Comment. Soc. Critt. Ital.* I (1861), 67.

On lepidopterous pupae. Steeton Whin near Tadcaster, July 1936 (W. G. Bramley). Hubberholme, September 1936.

Hirsutella acridiorum Petch, in *Trans. Brit. myc. Soc.* xvii (1932), 177.

On a cricket, Lartington, 16 September 1933. On a Homopteron, Aldeby, E. Norfolk, 7 July 1935; Surlingham Broad, 15 July 1944; Postwick Marshes, 16 August 1945 (E. A. Ellis).

**Hirsutella Aphidis* Petch, in *Naturalist* (March 1936), p. 60.

On aphids. Aldborough, E. Yorks., 12 September 1933. Brundall, 27 September 1943 (E. A. Ellis).

**Hirsutella dipterigena* Petch, in *Trans. Brit. myc. Soc.* xxi (1937), 53.

On flies (*Blepharoptera serrata*) in caves. Pinhole Cave, Cresswell, Derbyshire, 24 March 1924 (Leslie Armstrong). In a 'stalactite cave', Yealhampton, Devon, June 1906 (Herb. B.M.).

**Hirsutella lecaniicola* (Jaap) Petch, in *Trans. Brit. myc. Soc.* xviii (1933), 53.

The conidial stage of *Ophiocordyceps clavulata* (Schw.) Petch. With the perithecial stage on *Lecanium* on wych elm, Batheaston, Somerset, March and October 1860 (Broome).

Syngliocladium araneorum Petch, in *Trans. Brit. myc. Soc.* xvii (1932), 177.

On a spider among dead leaves, St Leonard's Forest, Horsham, 31 May 1931.

**Syngliocladium Cleoni* (Wize) Petch, in *Trans. Brit. myc. Soc.* xxv (1942), 265; *Acremonium Cleoni* Wize, in *Bull. Acad. Sci. Cracovie* (1905), p. 352.

On wireworms (*Agriotes* sp.), Rothamsted, February 1941 (H. C. Gough), with the sclerotial stage, *Sorosporaella uvella* (Krass.) Giard. On larvae of wireworms (*Corymbites cupreus* F.), Cardiff, 26 August 1942 (S. J. Hughes).

TUBERCULARIACEAE

**Aegerita insectorum* Petch, in *Trans. Brit. myc. Soc.* xxi (1937), 63.

On larva of *Urophora solstitialis* L. (Diptera), Cambridge, March 1935 (F. T. Brooks). On larva of *Stenichneumon trilineatus*, St Andrews, 18 January 1936 (Miss D. J. Jackson).

Microcera coccophila Desm., in *Ann. Sci. nat. Ser. 3*, x (1849), 359.

In England, usually on *Chionaspis salicis* on willow in the south-west. No further records.

DEMATIAE

[*Cladosporium Aphidis* Thuem., in *Oester. Bot. Zeitschr.* xxvii (1877), 12.

This is *Cladosporium herbarum* Link, and, on aphids and flies at least, it usually follows an attack of *Empusa* or *Entomophthora*; cf. Petch in *Trans. Brit. myc. Soc.* xix (1935), 190.]

FUNGI PARASITIC ON ENTOMOGENOUS FUNGI

Melanospora parasitica Tul., *Selecta Fung. Carp.* III, 10.

On *Spicaria* (*Isaria*) *farinosa*, Rawcliffe near Goole, 4 August 1934. On *Beauveria Bassiana*, Dartington, 25 September 1935. On ? on beetles (*Plateumaris braccata*), Wheatfen Broad, 9 and 13 August 1942 (E. A. Ellis). On *Isaria tenuipes*, Wheatfen Broad 20 September 1942 (E. A. Ellis). On *Beauveria densa* on a caddis fly, Wheatfen Broad, 18 October 1942 (E. A. Ellis).

**Sphaeroderma fusisporum* Petch, in *Naturalist* (March 1936), p. 58.

On *Spicaria* (*Isaria*) *farinosa*, Hirst Wood, Saltaire, September 1935 (W. P. Winter); North Wootton, 18 October 1936. On *Syngliocladium Cleoni* on wireworms from Rothamsted, February 1941.

**Stilbella ramosa* (Peck) Petch, in *Trans. Brit. myc. Soc.* XXI (1937), 53; *Stilbum ramosum* Peck, *Bull. Soc. Nat. Sci. Buffalo*, 1 (1873), 69; *Stilbella Kervillei* (Quélet) Lingelsh., in *Ber. Deutsch. Bot. Gesell.* XXXIX (1921), 149; *Stilbum Kervillei* Quélet, in Gadeau de Kerville, *Bull. Soc. Amis d. Sc. Nat. Rouen* (1884), pl. 1 (extr.); *Stilbella Arndtii* Lingelsh., in *Ber. Deutsch. Bot. Gesell.* XXXIX (1921), 149; *Stilbella setiformis* (Vahl) Petch, in *Trans. Brit. myc. Soc.* XVIII (1933), 55; *Clavaria setiformis* Vahl, in *Naturhist. Selsk. Skrivt.* II (1793), 50.

Parasitic on species of *Hirsutella* and on *Cordyceps* which have a *Hirsutella* conidial stage. On *Hirsutella dipterigena* on *Blepharoptera serrata*, Cresswell Caves, Derbyshire, 1923 (F. A. Mason in *Journ. Bot.* (August 1931), p. 205); Pinhole Cave, Cresswell, 24 March 1934 (Leslie Armstrong).

It is probable that the transfer to *Stilbella* has been made in America prior to that cited above.

Sporotrichum Isariae Petch, in *Naturalist* (April 1931), p. 102.

On *Spicaria farinosa* on gnats, Pinhole Cave, Cresswell, April 1934 (Leslie Armstrong). On *Spicaria* (*Isaria*) *farinosa*, Rawcliffe near Goole, 4 August 1934. On *Spicaria* (*Isaria*) *farinosa*, Upton Broad, 8 August 1940 (E. A. Ellis). On *Spicaria* (*Isaria*) *farinosa* on Homopteron (*Acocephalus nervosus*), Old Lakenham, Norwich, 18 October 1938 (E. A. Ellis). On *Aphrophora alni*, Wheatfen Broad, 20 April 1939 (E. A. Ellis).

NEW SPECIES

***Verticillium menisporoides* Petch, n.sp.**

On a dead spider, subaritime fen, St Olave's, Suffolk, 18 July 1944 (E. A. Ellis).

Spider covered by a rather loose greyish web, from which arise erect conidiophores, especially along the legs. Conidiophores up to 600 μ high, gregarious but distinct; stem hyaline, 3-4 μ diameter below, 2 μ diameter

above, septate, rigid, bearing whorls of phialides and, towards the base, short lateral branches, 12μ long, with an apical group of phialides. Phialides four or five in a whorl, conoid, tapering to the apex, not septate, $25-30\mu$ long, 2.5μ diameter below. Conidia apical, hyaline, continuous, persisting parallel in ovoid clusters, cymbiform or arcuate, produced at each end into a long point, $12-20 \times 2-2.5\mu$, with some narrow-oval, ends not produced, $9-12 \times 2\mu$, in the same cluster.

Mycelio laxo cinereo araneam obducente; conidiophoris ad 600μ alt., gregariis sed non fasciculatis, stipite hyalino, septato, rigido, infra $3-4\mu$ diam., supra 2μ diam., phialides verticillatos, et ad basin ramulos breves ferentibus; phialidibus quatuor v. quinque verticillatis, conoideis, ad apicem attenuatis, $25-30\mu$ long., infra 2.5μ diam.; conidiis apicalibus, hyalinis, in fasciculos parallele persistentibus, cymbiformibus vel arcuatis, utrinque longe attenuatis, $12-20 \times 2-2.5\mu$, vel anguste ovalibus, $9-12 \times 2\mu$, non attenuatis.

On a spider, Suffolk, England.

NOTES ON THE FOREGOING RECORDS

Entomophthora sphaerosperma Fres.

An epidemic of *Entomophthora sphaerosperma* on caterpillars of *Pieris brassicae* on *Brassica* in Kent was reported to the Plant Pathology Laboratory, Harpenden by Mr S. G. Jary in September 1945. The details in the following paragraph are taken from Mr Jary's report.

The caterpillars were observed to be dying in one corner of a field of 15 acres on 31 August and by 5 September the disease had spread over the whole field. The caterpillars turned brownish, some showed signs of mycelium, and others were entirely covered by mycelium and fastened by it to the leaves. Many failed to pupate, and numbers of pupae were obviously dead, and disintegrated when touched, being filled with a brownish fluid. Near the corner of the field, where the disease was first observed, it seemed that almost every caterpillar had been killed, very few caterpillars or pupae being found on trees.

Larvae of *Pieris brassicae* are the standard (original) host of *Entomophthora sphaerosperma*, and epidemics of the disease have been reported on several occasions on the Continent, but they have not been previously recorded in this country. On the other hand, *E. sphaerosperma*, as at present understood, is one of our commonest species of *Entomophthora* and occurs on insects of all kinds, though I had never before seen it on caterpillars. There is, however, a record of its occurrence on a small green caterpillar on grass (*Trans. Brit. myc. Soc.* vi, 202), and in September 1946 I received specimens on the larvae of *Plutella maculipennis* from Scotland per Dr C. E. Foister. They were of normal consistency, and bore the typical primary and secondary conidia, but no resting spores. On the other hand, the specimens received from Mr Jary were squashy, with a fringe of hyphae fastening them to the leaf and an external yellowish crust of resting spores, but primary and secondary conidia and cystidia could not be found, the whole mass being more or less disorganized.

The original description of *Entomophthora sphaerosperma* by Fresenius was apparently based on specimens in a similar condition to those from Mr Jary—hence the inappropriate epithet. The disease was subsequently investigated by Brefeld, who also worked with *Pieris* larvae and apparently added details of the primary and secondary conidia. But the rarity of epidemics on *Pieris* larvae in this country, in spite of the abundance of the fungus on other hosts, and the difference in its effect on these other hosts, suggest that there is more than one fungus included under this name. It should be ascertained whether the primary conidia and cystidia occur on *Pieris* larvae in an early stage of the disease, before the production of the resting spores.

Tarichium megaspermum Cohn.

This species was described by Cohn in 1875. It occurred in Germany in the larvae of *Agrotis segetum* which were turned black by the spores, and the disease has been styled the Black Muscardine. It does not appear to have been observed again in Europe before its present occurrence, but it has been recorded on cutworms at the Manitoba Agricultural College, Canada. It has not been redescribed, and is known only from Cohn's description and figures. Cohn's description, as summarized in Thaxter's monograph, stated that 'The resting spores are apparently azygospores borne laterally or terminally from hyphae and are peculiar on account of their dark brown episporium which is marked by sinuous furrows. The episporium is also frequently opaque showing no furrows. The spores are spherical and of large size measuring from 34 to 55 μ , average 50 μ .' Other available translations, e.g. Winter in Rabenhorst, Cooke, Guéguen, make no mention of smooth spores.

What appears to be this species was forwarded to me from the Plant Pathology Laboratory, Harpenden, having been collected by Mr S. G. Jary in larvae of *Plusia gamma* on *Pisum*, Romney Marsh, Kent, at the end of July 1946. The spores are spherical or slightly ellipsoid, black or black-brown, 36–50 μ diameter. They are at first loosely contained, singly or in pairs, in a pale brown, thin-walled, smooth mother cell, which is ellipsoid or produced at one end into a cylindrical or conico-cylindrical appendage. They soon become free, and numerous empty mother cells occur among the black spores. The actual spore is black, but the external black material appears to be a deposit, not a spore wall. Beneath the black substance is a thin, brown, smooth episporium, followed by a hyaline inner wall, 3 μ thick. The mother cells are evidently produced terminally or laterally on hyphae as figured by Cohn, but in no instance have I seen this cell wall furrowed, and the wall of the spore beneath the black deposit is smooth. I would suggest as a possible explanation that the spore wall observed by Cohn was the wall of the mother cell, artificially wrinkled by drying or some other means.

It has been supposed that *Tarichium megaspermum* is the azygospore stage of an *Entomophthora*, and the name *Tarichium* has been used generically for resting spores (real and alleged) of Entomophthoraceae. But the present specimens suggest that *T. megaspermum* should be placed in the Chytridiales.

I have received, per the Imperial Mycological Institute, specimens on lepidopterous larvae, Kenya, collected by Dr R. M. Nattrass, Nairobi, December 1945, matching those from Romney.

Oospora ovorum Trabut.

In this specimen the fungus formed minute, scattered, white, loose, pulvinate tufts, or clavate, isarioid clavae up to 0.25 mm. high, 0.12 mm. diameter above, 0.05 mm. diameter below, with globose or slightly oval conidia, 0.8–1 μ diameter, in long branching chains, terminal on hyphae 1 μ diameter. Compare *Trans. Brit. myc. Soc.* xxiii, 143.

Acremonium araneorum Petch.

Mycelium in this specimen loose, floccose; hyphae 3 μ diameter, collapsing in sections; phialides lateral on the hyphae, scattered or clustered, base oval, 3.5–4 μ high, 2 μ diameter, with a short sterigma, collapsing into a hair-like thread; conidia globose, 3 μ diameter, or oval, 3–4 \times 2.5–3 μ , rather thick-walled. This has the same structure as *Acremonium album* Preuss. It would seem that a new genus might be established for these species of *Acremonium* which have collapsing phialides.

Beauveria densa (Link) Picard.

In 1935–6, I received the Le Moulton culture of *Isaria densa* from two sources and was surprised that the fungus should have been placed in *Beauveria*, but after examination of old cultures of other species of *Beauveria* I concluded that it had 'run out'. In 1942, however, I received specimens on cockchafer adults and larvae from Mr J. M. B. Brown which agreed with the Le Moulton culture. It appears therefore that the latter has not 'run out', and that it is not a *Beauveria*. The fungus (or fungi) on cockchafers requires further investigation, which I regret I cannot now undertake.

Isaria fumoso-rosea (Wize) Vassil.

In recording this species for Britain in *Trans. Brit. myc. Soc.* xxvii, 90, I stated that the spores of the British specimens were white in mass, and therefore the record was doubtful, as the fungus is known in Russia as the Pink Muscardine. Mr E. A. Ellis has since sent me further specimens on glow-worms, all of which are decidedly pink, except in one collection in which they vary from faintly pink to white. Presumably the pink colour fades.

Isaria ochracea Boud.

This specimen, on an imago of *Sphinx ligustri*, was found dead in Norwich and taken to the Museum. The under surface bears numerous pale brown, short, laterally flattened clavae, with some taller and expanding above into a brush, but not forming a head. The conidia now present are oval, 3–4 \times 1.5–2 μ , in chains. Clusters of prophialides and phialides occur along the hyphae of the clava, the prophialides being globose, 3 μ diameter, and the phialides narrow flask-shaped, 5–6 \times 2 μ . The conidiophore has the same type of structure as in *Isaria tenuipes* and *I. ochracea* (as figured by

Boudier). The conidia differ in shape from those of *I. tenuipes*, but are the same shape as those of *I. ochracea*. Boudier, however, gave the size of the conidia of the latter as $6-8 \times 4-4.5 \mu$.

Hirsutella subulata Petch.

This species was described in 1932 from a specimen in Herb. Kew. collected before 1881, and the only conidia found measured $2.5 \times 1 \mu$. Later two American specimens in the Farlow Herbarium, one dating from 1890, were found to have conidia $4-6 \times 1.5-2 \mu$ and $4 \times 1.5 \mu$ respectively (*Trans. Brit. Soc. myc.* xxi, 123). More recently, Miss V. K. Charles, working with fresh material in America, has found the conidia to be $5-6 \times 2-2.5 \mu$.

Hirsutella Saussurei (Cooke) Speare.

This fungus, which occurs frequently on wasps and hornets in tropical countries, was found on several occasions by Mr E. A. Ellis on Ichneumonidae and small Hymenoptera on marshes near Norwich during May-October, 1945. The clavae were usually short, compared with tropical examples, but on one specimen they were up to 15 mm. long. In four collections, the conidia were cymbiform or narrow-oval, $6-9 \times 2-2.5 \mu$.

Speare, who examined specimens on *Polistes* in Hawaii, and others on *Polistes* spp. from North Carolina, California and the West Indies, stated that this species was readily distinguished by its long, narrow and usually allantoid spores, and he gave their dimensions as $9-11 \times 1-1.5 \mu$. There would seem a possibility, therefore, that '*Hirsutella Saussurei*', as at present understood, is a 'collective species'. The following spore measurements were made on some of the specimens I have examined during the last sixteen years. I give the dates of collection and examination, as they may have some bearing on the results obtained.

On *Polistes*, Fiji, allantoid or cymbiform, $6-7 \times 1.5 \mu$; 1923; Nov. 1930.

On wasp, Panama, narrow-oval or cymbiform, $3-5 \times 1-1.5 \mu$; Feb. 1917; Nov. 1930.

On small Hymenopteron, Trinidad, narrow-oval, $3.5-5 \times 1-1.5 \mu$; Oct. 1916; Nov. 1930.

On Hymenopteron, Trinidad, cymbiform, $5-6 \times 1.5 \mu$; Jan. 1919; Nov. 1930.

On wasp, Trinidad, oblong-oval or allantoid, $4-7 \times 1-1.5 \mu$; Jan. 1921; Feb. 1931.

On Hymenopteron, Venezuela, cymbiform, $6-7 \times 1.5-2 \mu$; Aug. 1932; April 1934.

These specimens, in order, were Williams, nos. 42, 43, 44, 66; Wakefield, no. 44; and Venezuelan Fungi, no. 1443.

The conidiophore of a *Hirsutella* is very fragile, and unless treated carefully the head of conidia is readily broken off. Perhaps the larger heads are lost first. But it would seem possible that the conidia may increase in size after abstriction, while in the globule of mucus which forms the head. However, the conidia in the British specimens of *H. Saussurei* are more broadly cymbiform than in the tropical forms.

Hirsutella citriformis Speare.

A number of examples of this species, which is usually associated with warmer countries, were found by Mr E. A. Ellis on a marsh near Norwich on *Homoptera*, including *Kelisia scotti* (Fieb.) and *Araeopus pulchellus* Curt., and a Heteropteron, *Nabis lineatus* Dahlb. The somewhat rigid, hair-like, brown clavae were up to 20 mm. long.

As far as I am aware, this species has not been previously reported in Europe. A fungus of similar appearance, *Isaria stilbiformis*, was described by Spegazzini from a specimen on a small Pentatomid in Italy. Spegazzini described his species as 3-7 mm. high, the hyphae of the compound stem diverging at the apex and forming a subglobose or pyriform head, the apices of the hyphae being clavate, and each bearing a cylindrical, subacute, hyaline conidium, $8-11 \times 2-2.5 \mu$. There seems little doubt that the fungus was a *Hymenostilbe*. Typically, the basidia of a *Hymenostilbe* are situated uniformly along the clava, but I have seen examples in which they were collected into a terminal head in *H. melanopoda* and *H. formicarum*.

Mr Ellis points out that these specimens of *Hirsutella citriformis*, collected October 1945, came from the same locality as his specimens of *H. acridiorum*, collected August 1945, and suggests that these may be forms of the same species. In *H. eleutheratorum*, a mucedinous form was found in the catacombs of Paris and was named *Isaria Guignardi* Maheu, but there does not appear to have been any similar difference in environment of the collections recorded here, which both occurred in living leaves.

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ADDENDUM

**Cordyceps memorabilis* Ces., *Comm. Soc. Critt. Ital.* 1, (1861), 16.

On a carabid larva, Wheatfen, Norfolk, 10 September 1947 (E. A. Ellis).

LIST OF BRITISH FUNGI PARASITIC ON LICHENS OR WHICH HAVE BEEN INCLUDED AS LICHENS (OR VICE VERSA), WITH SOME NOTES ON THEIR CHARACTERS AND DISTRIBUTION

BY W. WATSON, D.Sc.

Little attention has been paid for many years to the fungi occurring as parasites on lichens in the British Isles, either by lichenologists or mycologists. During the last century a few fungal parasites on lichens were described by Mudd (1861), Lindsay (mostly in 1869) and others, but it was not till this century that any serious attention was paid to them. A. L. Smith in 1910 gave an account of some in these *Transactions* (54a); in her first edition of *British Lichens*, vol. II (1911) about twenty parasitic fungi were mentioned, and in the second edition (1926) the list was extended to about sixty, but many others were included as lichens in the general text. In the lists of Pyrenomycetes and Hyphomycetes published in these *Transactions* for 1940 and 1941 the names of some of our fungal parasites were given, some have been incidentally mentioned in my Lichenological Notes published in the *Journal of Botany* and elsewhere, but many British species have been entirely ignored.

Amongst foreign authors during the latter part of the last century valuable contributions were made to the study of these lichen parasites by Rehm, Saccardo and Zopf, but the most thorough work must be attributed to the later studies of Olivier (1905-7), Vouaux (1912-14) and Keissler (1930). *Die Flechtenparasiten* of the last-named refers to many British records and is of such an excellent standard that its arrangement and nomenclature are usually followed even when they differ from those adopted by British mycologists. Other names in use or which have been used by British botanists are given so that any reference to a British plant can be traced. Prominence is given to British references and foreign ones have been largely ignored, often even when the nomenclature used depends on one, though this reference can be obtained through the references given. Some account of their distribution in Great Britain and Ireland has also been included. In most instances when no good description is readily available one has been added.

SYSTEMATIC ARRANGEMENT (AFTER KEISSLER)

Basidiomycetes

Ascomycetes

Discomycetes

Pezizinae: Celidaceae, Helotiaceae, Mollisiaceae, Patellariaceae.

Phacididiinae: Stictidaceae.

Pyrenomycetes

Perisporiales: Eurotiaceae, Perisporiaceae, Microthyriaceae.

Hypocreales

Dothideales: Phyllachoraceae.

Pseudosphaeriales

Pyrenomycetes (*continued*)

Myriangales

Sphaeriales: Sphaerellaceae.

Pleosporae: Pleosporaceae.

Fungi imperfecti

Sphaeropsidales

Melanconiales

Hyphomycetes

Phycomycetes are not included, but occasionally some species may be found on lichens though they are not really parasitic on them.

Keissler's *Flechtenparasiten* includes some Myxobacterales and Myxomycetes as lichen parasites and gives some British references for them.

Myxobacterales: *Chondromyces aurantiacus* Thaxt. in **23**, 33; *Stigmatella* Berk. & Cke. in *Introd. crypt. Bot.* (1857), 313; *Polycephalum* Kalchb. & Cke. in **14**, xiv (1884), 23; ? *Stilbum rhytidiospora* Berk. & Br. in *J. Linn. Soc. (Bot.)*, xiv (1873), 96.

Myxococcus fulvus Jahn. in **23**, 34; *M. pyriformis* A. L. Sm. in **20** (1901), 71. Miss Smith's plant was found at Llanwymawddwy, Merionethshire, in 1899, on rabbit pellets and not on a lichen.

Myxomycetes: *Hymenobolina parasiticus* Zuk. in Lister, *Mon. Myc.* 3rd ed. (1925), 181; *Hymenobolus parasiticus* Zuk. in Lister, *Mon. Myc.* 2nd ed. (1911), 262. This is given as parasitic on lichens, but no British locality is given for this habitat.

Listerella paradoxa Jahn. in Lister, *Mon. Myc.* 2nd ed. (1911), 262; 3rd ed. (1925), 251. This occurs on *Cladonia podetia*, but no British locality is given.

Didymium melanospermum Macbride in Lister, *Mon. Myc.* 2nd and 3rd ed. (1925).

Craterium minutum Fr. in Lister, *Mon. Myc.* 3rd ed. (1925), 95.

Badhamia capsulifera Berk. in **68**, xxi (1852), 153; in Lister, *Mon. Myc.* 3rd ed. (1925), 10; *B. hyalina* in Berk. loc. cit.; in Lister loc. cit.

B. utricularis Berk. loc. cit.; Lister loc. cit.

B. versicolor Lister in **20**, xxxix (1901), 81; Lister, *Mon. Myc.* 3rd ed. (1925). Occurs on bark and lichens in Aberdeenshire.

In the following list fungi which have been included as lichen parasites but are not really so are usually enclosed in square brackets. A similar method has been employed for fungi which have been considered as lichens and for lichens which have been included in fungi. Lichens which appear to be parasitic occasionally occur but are rare. One of the most striking examples seen was noted near Llangollen where *Biatora viridescens* Fr. was growing over a *Fomes*.

BASIDIOMYCETES

HYMENOMYCETINEAE

THELEPHORACEAE

Coniophora laxa (Fr.) Quel.; *Corticium* Fr. **52**, 626 (with description), is included in Keissler's list. It does occur on lichens but is probably entirely saprophytic.

Corticium arachnoideum Berk. 52, 676; 1, xiii, 344; 41, 1, 122 (with description); *C. centrifugum* (Lév.) Bres., *Rhizoctonia* Lév., *Sporotrichum lichenicolum* Berk. & Br. in 21, xiv (1872), 122, apud 23, 523. Occurs on corticolous lichens, especially *Xanthoria parietina*, but also on many other lichens.

ASCOMYCETES

DISCOMYCETES

PEZIZINEAE

CELIDACEAE

[**Agyrium rufum** Fr. This fungus, which is given as a saprophyte on wood in 41, iv, 170, is included as a lichen, as it occasionally occurs associated with a lichen thallus, in 20 (1867), 257; 31, 392; 8, 10. The following localities are given for this supposed lichen: Knighton, v.c. 43; Dolgelly, v.c. 48; Achrosagan, v.c. 98; Ballynahinch in I, v.c. 16 and Killarney in I, v.c. 2.]

Celidium lichenum (Somm.) Schroet., *Dothidea* Somm. in 23, 89; *C. stictarum* Tul. apud Linds. 68 (1866), 506; *Sphaeria* DN.; *C. dubium* Linds. 69 (1866), 449; *Homostegia* Cke. 14 (1886), 66. *Sticta pulmonacea* var. *pleurocarpa* Ach. is a state of the lichen, *Lobaria pulmonaria*, in which the apothecia are abortive, tuberculose-diform and brownish owing to the attacks of this fungus, 9, 272; 55, 116. This state has been noted on specimens from Bocconoc (2), Hafod (46), Cwm Bychan (48), Trosacks (87), Cawdor (96) and Appin (98). Lindsay also records the fungus as parasitic from v.c. 90.

[**C. squamaricolum** Linds. 50 (1869), 142 is expunged by Keissler. According to Vouaux it is a sterile mycelium, formerly placed in *Antennaria* and now in *Racodium*, 71.]

C. varians (Nyl.) Arn. 41, iv, 10; 78, 62; *Lichen*, Hall, *Brit. Fl.*; Davies in 68 (1794); *Arthonia* Nyl. in 57, 240; *Arthonia* Nyl. 1856 ex Leighton in 1 (1856), 330; *Lecidea epipasta* Stirt. 21 (1874), 368; *Arthonia galactinaria* Leight. p.p. 31, 426; *Conida* Vouaux, 57, 390. Description in 56, 218-19. Parasitic on the thallus of *Lecanora rupicola* (*glaucoma*) with records from the following vice-counties: C, 1, 2, 4, 40, 42, 45, 48, 49, 52, 62, 69, 71, 91, 92, 98, 100; Ireland, 3, 6, 12, 16, 21, 27, 35, 38. Form *parasemoides* (Nyl.) Arn. 23, 96; *Arthonia parasemoides* Nyl. in 42, 252. Differs from the type by the paraphyses being almost absent and the spores 2-septate, the middle cell somewhat greater. Usually on the apothecia of *Lecidea parasema*. From Gunwalloe, v.c. 1, Longmynd, v.c. 40, Cleveland, v.c. 62, and Lerwick, v.c. 112.

C. varium (Tul.) Massal. 23; 71; 57, 390; *Phacopsis* Tul. in 23; *Lecidea glaucomaria* Nyl. 1852 in Leighton 69 (1878), 238; 31, 389; *Leciographa* A. L. Sm. 56, 186 and 57, 202 (which see for description). Note that *Lecidea glaucomaria* Nyl. of 1852 corresponds with this fungus whilst the *Arthonia glaucomaria* Nyl. of 1856 corresponds with *Celidium varians*. Both occur on the same species of *Lecanora*, but *C. varium* is found

on the thallus whilst *C. varians* occurs on the apothecia. As the spores are 3-septate and brown the species goes under the subgenus *Celidiopsis* Sacc. Recorded from the following v.c.: 5, 45, 48, 71, 90, 96 and I, 16, 21.

[*Conida abrothallus* Linds. is given by Arnold in *Flora* (1878), 104, by the name alone and is discarded by Keissler in 23, 86.]

Conida clemens (Tul.) Massal., *Phacopsis* Tul. 23, 72; *Arthonia punctella* Nyl. in 5 (1859), 553; 42, 252; 57, 241; *A. subvarians* Nyl. in 56, 219; 57, 241; *A. galactinaria* Leight. p.p. 31, 426; ? *Microthelia subfuscicola* Linds. 50 (1871), 39; *Conida punctella* Arn. in 56, 346 and 57, 390. Lindsay records it as occurring on the thallus of various Lecanoras, but it also occurs on many other lichens. Both *C. punctella* Arn. (with somewhat broader spores and hyaline hypothecium) and *C. galactinaria* Arn. (with spores becoming brownish) are included by Keissler in this variable plant. Recorded from v.c. 5, 14, 33, 48, 52, 71; I, 5, 16, 21, 27.

C. epiphorbia (Stirt.) Vouaux, 71; 57, 390; *Lecidea* Stirt. 14 (1873), 108; 31, 388; 56, 104; 57, 111; *Karschia* Zopf in 51, 378. On *Solorina bispora* Ben Lawers. Keissler considers that the species is insufficiently described.

C. fuscopurpurea (Tul.) Vouaux in 57, 390; *Celidium* Tul. in Linds. 50 (1869), 141; *Arthonia peltigerea* Th. Fr., *Scutula* Rehm in 57, 241 and 389; *Homostegia pelvetii* (Hepp) Linds. in 4, 206 with further references; *Conida pelvetii* Arn. is included in 23, 77 as a synonym. On thallus of *Peltigera* and *Solorina*, Corriemulzie, v.c. 92. Form *stereocaulina* (Ohl.) Keissl. *Arthonia nephromaria* var. Ohl. differs from the type by the hymenium becoming red straightway with iodine and in its habitat on *Stereocaulon* or occasionally on *Physcia*.

HELOTIACEAE

Pezizella epithallina (Phil. & Plow.) Sacc., *Peziza* Ph. & Pl. 14 (1887), 24; *Mollisia* Phil. 47, 173; *Mollisiella* Boud. in 51, 377; *Peziza miliaris* Wallr. in 23, 108; 47, 458. Collected by Plowright at King's Lynn.

MOLLISIIACEAE

Orbilbia coccinella (Somm.) Karst. 51, 372; 41, IV, 144; *Peziza* Somm., *Calloria* Phil. 47, 328-9. Usually on dead wood but *sec.* Rehm also on crustaceous lichens where it is probably saprophytic rather than parasitic.

PATELLARIACEAE

Nesolechia associata (Th. Fr.) Sacc. & D. Sacc., *Lecidea* Th. Fr. in 23, 138; *L. leptostigma* Nyl. in 57, 52; *Nesolechia leptostigma* Sacc. as synonym in 71 (1913), 415 and 23. A. L. Smith puts this in the *Biatora* section, gives references to Crombie and Leighton, states that it occurs on *Ochrolechia tartarea* on a mica-schistose boulder on Ben Lawers and suggests, as Nylander thought the thickish thallus was not proper, that the apothecia belong to a fungus parasitic on a sterile thallus.

- N. cetraricola** (Linds.) Arn. in 57, 389; *Lecidea* Linds. 50 (1869), 57 and (1871), 35; 68 (1871), 364 and Pl. 48. On *Cetraria islandica* and *C. juniperina* at Braemar, v.c. 92. The description is insufficient for the species to be included in Keissler's key.
- N. cladoniaria** (Nyl.) Arn. in 57, 111 and 389; *Lecidea* Nyl. in 8, 94; 30, 358; 56, 104; 31, 388; *Abrothallus cladoniarius* Linds. 39, xxv, 546; ? *Ab. moorei* Linds. 39 (1869), 554. Parasitic on *Cladonia*, Kelly's Glen near Dublin.
- ? **N. insita** Vouaux, 71; 57, 389; *Lecidea* Stirt. in 63 (1879), 17; 31, 545 and 57, 112. Parasitic on *Peltigera aphthosa* and collected by Stirton at Creag-na-Lochan, v.c. 88. It is listed as a lichen in British lichenological works and may be a form of *Biatora geophana* (Nyl.) Fr. The thallus of the latter is often so indistinct that the position of the plant is rather doubtful. A plant collected in 1928 on marly soil at Orchard Portman, v.c. 5, was considered at that time to be a fungus, but recently a re-examination showed that it was identical with a specimen of the Little Bowden plant described as *Lecidea pleiospora* A. L. Sm. in 20, XLIX, 41 and 56, 352, and later placed under *L. geophana* Nyl. in 57, 51.
- [? **N. intumescens** Magn., *Lecidea intumescens* (Flot.) Nyl., *L. badia* var. *intumescens* Flot., *L. insularis* Nyl. in 56, 94 and 57, 104. Magnusson suggested that this was a *Nesolechia*, but, though it is apparently parasitic on Lecanoras and other lichens and partially destroys the thallus over which it grows, it is considered to be a true lichen. The designation *Lecidea insularis* is adopted by A. L. Smith, as Nylander's *insularis* dates from 1852 whilst *intumescens* was not used as a specific name till 1876.]
- N. lichenicola** (A. L. Sm. & Ramsb.) Keissl. 23, 140; *Discocera* A. L. Sm. & Ramsb. in 59 (1917), 48; 77, 93. Found in 1915 and 1916 on lichen-thallus on stone at three different places near Taunton, Britty Common, Feltham and Treborough. The lichen was sterile in every locality and was not determinable. Keissler states that it is 'eine sehr merkwürdige Art'.
- N. neglecta** Vain. 70, iv, 418-19; 74, viii, 152. '*Lecidea neglecta* Nyl.' in Crombie, 10, xiii, 141; Leight. 31, 276; A. L. Sm. 56, 96 and 57, 106, refers to the thallus on which the apothecia of the fungus are situated. This is given by Lynge in 70, iv, 419 as *Crocynia neglecta* (Nyl.) Hue; but also see 74, tom. cit.
- N. oxyspora** (Tul.) Massal. 71; 23; 57, 111 and 389; 78, 62; *Abrothallus* Tul. in 38 (1857), 37; 42, 225; *Lecidea* Nyl. in 56, 103; 57, 111; 8, 92; 30, 357; 31, 384. *Lecidea obscurioides* Linds. in 69, xxii (1859), 247 and Pl. XIII, figs. 36-8. This was described from a specimen collected by Carroll at Dunscombe Wood, Cork. Lindsay's description agrees quite well for *N. oxyspora*, though the spore measurements are rather smaller. Parasitic on various Parmelias and recorded from v.c. 1-3, 35, 37, 48, 49, 64, 72, 81, 87-92, 97, 98, 101, 104, 110; Ireland 1, 3, 16.

- N. puncta** Massal. in **23**, 126. A specimen from Redhead, Forfarshire, was considered by Lamb to belong here probably, but the hymenium is not coloured by iodine. *N. inquinans* Massal., if synonymous, appears to have priority.
- N. vitellinaria** (Nyl.) Rehm, **71**; **23**; **57**, 389; **78**, 62; *Lecidea* Nyl. **42**, 212; **8**, 78; **30**, 355; **31**, 384; **56**, 60; **57**, 110. Parasitic on the thallus of *Candelariella vitellina* and also on other crustaceous lichens. Recorded from v.c. 1, 35, 37, 40, 62, 88-90.
- Var. **supersparsa** (Nyl.) Keissl. *Lecidea* Nyl. in **23**, 133, has spores which are more or less rhomboid and acute at their apices. A specimen collected by Miss Duncan from Lundie Crags has been seen by me.
- Scutula cristata** (Leight.) Sacc. & D. Sacc. **51**, 379; **74**, vi, 71; **77**, 93; *Lecidea* Leight. **31**, 385; *Biatorina* A. L. Sm. **57**, 143; *Catillaria* Arn. (see **74**, vi, 71). On the thallus of *Lecanora subcarnea* at Barmouth, but on other species at the Lizard and Arbroath.
- S. epiblastematica** (Wallr.) Rehm, *Peziza* Wallr. **23**, 149; *Biatorina* A. L. Sm. **57**, 144; **77**, 38; ? *Lichen glebulosus* Smith, *Eng. Bot.* 1809; *Lecidea wallrothii* Nyl. **20** (1874), 148; **31**, 388; non **56**, 29 and **57**, 19; *L. heerii* Hepp. in **20** (1882), 274. On the thallus of *Peltigera* and *Solorina* on Craig Calliach, Glen Lyon and Ben Lawers.
- S. epicladonia** (Nyl.) Sacc., *Lecidea* Nyl., *Conida* Vouaux in **23**, 154; *Biatorina* Arn. in **74**, vi, 72, which see for description. On the squamules of *Cladonia pyxidata* var. *pocilla* at Portland, v.c. 9.
- S. episema** (Nyl.) Zopf in **23**, 160; *Lecidea* Nyl. in **20** (1867), 257; **8**, 78; **31**, 385; *Biatorina* A. L. Sm. **57**, 143; **77**, 38; *Catillaria* Oliv. in **74**, ix, 36; *Biatorina supernula* A. L. Sm. **57**, 143; *Lecidea* Nyl. in **31**, 389. On the thallus of *Aspicilia calcarea* and fairly common. Recorded from v.c. 5, 6, 33, 37, 41, 48-50, 88, 103; Ireland 1, 5, 7, 8, 10, 16, 17, 29.
- [**S. peltigerea** Rehm, *Arthonia* Th. Fr. in A. L. Sm. **57**, 241 is included by Keissler under *Conida fuscopurpurea*.]
- S. stereocaulorum** Krb. in Vouaux, **71** (1913); *Biatorina* Th. Fr. in **57**, 143, with description; *Lecidea* Nyl. in Crombie, **14**, xxii, 11. On the phyllocladia of *Stereocaulon*. No locality is given by A. L. Smith, but I have recently seen this parasite on a specimen of *S. denudatum* from Achnacashen, v.c. 106.
- Mycobilimbia endocarpicola** (Linds.) Vouaux in **57**, 389; *Lecidea* Linds. **39** (1869), 547 and **50** (1869), 136. This is incompletely described sec. Keissler. 'Found by Carroll in England on *Dermatocarpon hepaticum* and may have to go in the genus *Celidium*', **23**, 171.
- M. killiasii** (Hepp) Rehm, **23**. This has recently been noticed on a specimen of *Peltigera aphthosa* collected in 1929 from near the summit of Ben Lawers.
- [**M. obscurata** (Somm.) Rehm, *Lecidea sphaeroides* var. *obscurata* Somm. **23**, 171. This is included by Vouaux as a lichen parasite. Though it may grow on the thallus of *Peltigera*, Keissler considers it to be a true lichen. It is given in **83** by Zahl. as *Bacidia obscurata* and by A. L. Sm.

in 56, 143 and 57, 156 as *Bilimbia sabuletorum* var. *obscurata*. Another species, *Bilimbia effusa* Auersw. (in 77, 59), is not a lichen parasite as some authors state but a true lichen, 23, 172.]

[**Mycobacidia arenicola** (Nyl.) Sacc. in 51, 378; *Lecidea* Nyl. in 31, 386; *Raphiospora* Mudd, 42, 186. This is given by Vouaux as a lichen parasite, 71 (1914), 140, but is usually considered to be a lichen in which the thallus is obsolete, the apothecia often growing over the thallus of *Baeomyces*. It is given in 56, 165 and 57, 180 as *Bacidia flavovirescens* var. *arenicola* A. L. Sm.]

[**M. flavovirescens** (Dicks.) Rehm; *Lichen* Dicks. in 82; *Lecidea* Borr. in 61; *Raphiospora* Krb. in 42, 186; *Lecidea citrinella* Ach. in 8, 94 and 31, 366 is given by Vouaux and some other authors as a lichen parasite. It is a true lichen *sec.* Tobler and many other lichenologists. Though it may grow over the thallus of *Baeomyces* it often occurs where no *Baeomyces* is present. It is listed by A. L. Sm. (57, 179) as *Bacidia flavovirescens* Anzi, and is not uncommon in subalpine regions.]

M. vermifera Vouaux is given by Keissler under *Spilomela*.

M. plumbina Vouaux is given by Keissler under *Lahmia*.

Lahmia fuistingii Krb. in 23, 175. Spores at least 8-celled, 20–40 (–70) \times 2–2.5 μ , to 8-nae, more or less parallel above, hyaline, acicular. Ascus clavate, 90–100 \times 15–17 μ , above somewhat acute. Paraphyses septate. Hypothecium almost colourless. On *Baeomyces rufus*, Britty Common, near Taunton, Somerset.

L. plumbina Keissl. 23, 176; *Leciographa* Anzi in 56, 186; 57, 202; 51, 378; *Mycobacidia* Vouaux (1914) in 57, 390. On *Parmeliella plumbea* in Borrowdale, v.c. 70 and Lowther Park, v.c. 69. Description in 56, 186.

Mycomelaspilea leciographoides Keissl. 23, 218; *Melaspilea* Vouaux 71 (1913), 472; 83, II, 248. Apothecia mostly 2–3 or even to 6 aggregating or nearly so, sessile, at first punctiform but soon lengthened and lirelliform, with thick margin. Ascus 75–80 \times 23–28 μ . Spores 8-nae, biseriate, strongly constricted between the longer upper hyaline to brownish cell and the lower smaller cell, 19–22 \times 10–12 μ . Epithecium and hypothecium brownish. Iodine colours the contents of ascus and paraphyses blue then reddish brown, the ascus wall becoming blue and then yellow. On *Verrucaria*, Beetham, v.c. 69.

Karschia adjuncta (Th. Fr.) Arn.; *Buellia* Th. Fr. 23; 71; 74, VII, 332, which see for description. It is incompletely described by Th. Fr. *sec.* Keissler. The coloration of the hymenium with iodine is blue, whereas Vouaux gives it as negative. Known from v.c. 41 on *Lecanora expallens* and *L. conizaeoides*, and from v.c. 58 on the latter host.

K. advenula (Leight.) Zopf, 51, 378; *Lecidea* Leight. 68 (1876), 146; 31, 338; *Buellia* A. L. Sm. 57, 200; 74, VIII, 155. Keissler apparently followed A. L. Smith in giving the spores as 4-nae. They are given as 8-nae by Leight. 31, 388, and the type specimen at Kew seldom had less than 8 spores in the ascus when it was examined by me. On the thallus of *Pertusaria*, Llanbedrog, v.c. 49, Appin, v.c. 98 and Garrynahine, v.c. 110. In Ireland it was collected by Larbalestier in Connemara (I. 16) and in Mayo (I. 27); 25, 371. As an instance of confusion

- between lichens and lichen parasites *Lecidea epipsila* Nyl. (*Buellia* Oliv.) is mentioned by A. L. Smith in 56, 185 as being allied to *Buellia* (*Karschia*) *advenula*, both occurring on the same species of *Pertusaria*. Keissler, 23, 201, states that it is a lichen with a thallus of its own, even though this grows over the thalli of various crustaceous lichens, especially *Pertusaria wulfeni* form *rupicola* (= *P. sulphurea* Schaer.).
- K. athallina** (Mull.) Vouaux; *Buellia* Mull. 23, 183; *Lecidea particularis* Nyl. in 31, 386; *Buellia* A. L. Sm. 56, 184; 57, 200; 25, 370. On the thallus of *Baeomyces* at Kylemore and Dungannon in Ireland and recently collected by Sowter at Sandsend in Yorkshire, v.c. 62.
- K. destructans** Tobl., which occurs on *Chaenotheca*, is mentioned in 58, 265, but no British records are known to me.
- [**K. lignyota** (Fr.) Sacc. in 51, 378; 41, iv, 99; 75, iv, 208; *Patellaria* Fr. in 47, 360 was included amongst the lichens by Leighton as *Arthonia melaspermella* Nyl. in 31, 416.]
- K. saxatilis** (Rabh.) Rehm, *Trachylia* Rabh., *Calicium* Schaer. in 23, 191. *Calicium saxatile* Schaer. is given by A. L. Smith (57, 196) as a synonym of *Buellia saxatilis* Krb., and this is retained as a lichen by all British authors. The lichen parasite has not yet been recorded for the British Isles, though it probably occurs.
- [**K. scabrosa** Rehm in 23 and 71; *Buellia scabrosa* form *athallina* A. L. Sm. 57, 196. This is not a true parasite, but the lichen *Buellia scabrosa* Krb., growing over *Baeomyces rufus*.]
- K. talcophila** Krb. in 23, 189; *Lecidea ferdinandezii* Cromb. 21 (1877), 223. Crombie's reference is to a foreign specimen.
- K. thalloides** (Hepp) Rehm, 23, 199. A parasite on *Pilophorus* from Killarney agrees with this species except for the host which usually is *Physcia*.
- Abrothallus microspermus** Tul. 23, 213; 71 (1913), 468; *A. smithii* var. *microspermus* Linds. 50 (1857), 34 and 68 (1866), 507. On *Stictina fuliginosa* at Tavistock (specimen in herb. Kew.).
- A. moorei** Linds. 39 (1869), 554. On *Cladonia uncialis* and *C. bellidiflora*. Vouaux considers this as a synonym of *Phoma uncialicola*, but Keissler does not think Vouaux's theory possible as Lindsay gives to his species an ascus with spores. He considers that the species is better eliminated, though it may refer to *Nesolechia cladoniaria*.
- A. parmeliarum** (Somm.) Nyl. in 23; 71; 78, 62; *Lecidea* Somm. in 8, 92; 30, 357; 31, 386; *Buellia* Oliv. in 56, 183 and 57, 199; *Lichen parasiticus* Smith, *Eng. Bot.* (1808, and so prior to starting-point of fungal nomenclature); *A. smithii* Tul. in 1 (1852), 113 and 50 (1857), 34; Mudd, 42, 224; *Lecidea* apud Linds. in 69 (1859), 292; *Phymatopsis dubia* Linds. 69 (1866), 442; *Abrothallus parmeliarum* var. *ater* Linds. 38 (1857), 34; *A. welwitschii* Mont. is a nomen nudum sec. 23, 207, but was described later by Tul. as *A. welwitschii* Tul. Occurs on foliaceous and fruticulose lichens and is common. It has been recorded from 27 English, 13 Scottish and 8 Irish botanical counties. When it occurs on *Usnea* as it does at Llanbedr, v.c. 48, it has been styled *Abrothallus usneae* Rabh., *A. parmeliarum* form *usneae* by Rehm and Vouaux and *Buellia*

usneae by Jatta (74, vii, 332). Keissler includes this and some other creations with the type. Form *chrysanthus* (Stein.) Arn. has the apothecial disk remaining greenish golden pruinose right up to an old stage, whereas in the type the pruina is some other colour and is lost much earlier. Leighton's no. 191, 29, is probably this form *sec.* Keissler, 23, 212.

Leciograppha centrifuga (Mass.) Rehm, in 23, 240, probably occurs in our islands, but the only record is a doubtful one.

L. inspersa (Tul.) Rehm, in 23, 226; 71 (1913), 476; 26, ii, 165; *Lecidea* Flk. 1819, so before starting-point for fungal nomenclature; *Dactylospora* Mudd, 42, 224; ? *Calicium stigonellum* Salwey in 66 (1846), 204, non Schaer.; 29, no. 183; *Lecidea zwackhii* Cromb. 10 (1876), 362 non Massal.; *Leciograppha parasitica* Massal. in 56, 185; 57, 201; 77, 61 *sed* non Massal. (for description of *L. inspersa* see this). On the thallus of *Ochrolechia parella*, *Pertusaria* species, etc. Not uncommon and recorded from the following botanical v.c.: C, 1-3, 5, 11, 13, 14, 19, 23, 26, 33, 35-8, 44, 47-50, 55, 60, 62, 90, 92; Ireland, 2, 4-6, 15, 16, 20, 21, 35, 38, 39.

L. parasitica Massal. in 56 and 57 does not refer to Massalongo's plant but to *L. inspersa*. It occurs in our islands and the paucity of records is probably due to the confusion of the two species. It differs from *L. inspersa* as follows: epithecium and hypothecium brown, hymenial gelatine blue then wine-red with iodine, spores larger, $15-20 \times 5-9 \mu$.

L. parellaria (Nyl.) Sacc. & D. Sacc. in 71 (1913), 486 and 23, 236; *Lecidea* Nyl. in 10 (1876), 362; 31, 387; *Leciograppha parasitica* var. *parellaria* A. L. Sm. 56, 186; 57, 201. On *Ochrolechia parella*, Fishguard, v.c. 45 *leg.* Leighton, near Conway, v.c. 49 in Herb. Brit. Mus., Connemara, I. 16 *leg.* Larbalestier.

L. lamyi (Rich.) Sacc. & D. Sacc., *Lecidea* Rich. 71 (1913), 483 and 23, 230. A specimen from Arbroath on *Lecanora rupicola* seems referable to this species. Apothecia in groups of 3-10 with dark discs, 0.15-0.4 mm. Ascus may have 8 spores but often only 6 or 4. Spores 3-septate, without oil-drops, smooth-walled, elliptical, obtuse at both ends, hyaline at first but finally brown, $16-22 \times 6-9 \mu$. Hymenium with iodine blue then wine-red. Hypothecium dark brown. On *Lecanoras*.

[**L. scapanaria** (Carrington) A. L. Sm. 57, 202; *Lecidea* Carr. in 66 (1863), 382 and 411; 8, 87; 31, 387, is not a lichen parasite but is a fungus on a liverwort. *L. persimilis* Nyl. in 14 (1873), 71; 31, 389 is included by A. L. Smith. Recorded from vice-counties 88, 89; Ireland 2, 16.]

[**L. zwackhii** Vouaux, *Lecidea* Massal. 71 (1913), 480; 23, 229. *Lecidea zwackhii* is recorded by Crombie in 20 (1876), 362 as collected by Joshua and parasitic on the thallus of *Pertusaria* at Chedworth in v.c. 33, but it is not Massalongo's plant. *Sec.* A. L. Smith, Crombie's record probably refers to her *Leciograppha parasitica* (= *L. inspersa* Rehm).]

- Spilomela vermifera** (Leight.) Keissl. **23**, 221; *Melaspilea* Leight. **68** (1876), 146; **31**, 437; **57**, 251; *Scutularia* Sacc. in **51**, 378-9; *M. vermiformis* Leight. in **14** (1875), *sec.* **83** (1923), 284; *Mycobacidia vermifera* Vouaux **71** (1914), 141. On thallus and apothecia of *Pertusaria globulifera* on oak, Trefriw, v.c. 49.
- [**Biatorella campestris** Th. Fr. in **56**, 353; **57**, 115. This is considered by lichenologists to be a lichen, but the manner in which the apothecia develop (see **74**, vii, 328) is very similar to that of a parasitic fungus.]
- [**B. difformis** (Fr.) Wain., *B. fossarum* (Duf.) Rehm, *B. moriformis* (Ach.) Th. Fr., *B. pinicola* (Massal.) Th. Fr. and *B. resinae* (Fr.) Mudd are given by Ramsbottom in **51**, 379, amongst the fungi, but most lichenologists place them amongst the lichens; **8**, 75-6; **31**, 382-3; **42**, 191; **57**, 115-17, etc. Massee in **41**, iv, 95-6 includes *B. resinae* and *B. pinicola* amongst the fungi. *Sec.* A. L. Smith the terminology *B. fossarum* (Duf.) Th. Fr.; *B. resinae* (Fr.) Th. Fr. is correct.]
- [**Sphinctrina gelasinata** (Wahl.) Zahl., *Lichen* Wahl. in **83**, i, 581; *Sphinctrina turbinata* Fr. in **55**, 3 and *S. microcephala* Nyl. in **9**, 84; *S. tubaeformis* Massal. in **55**, 3 are lichens parasitic on *Pertusarias* and have been given by Rehm and other authors as fungal parasites; in fact, Rehm considers the genus as a fungal one.]
- [**Stenocybe major** Nyl., *S. euspora* Anzi in **23**, 643 and other species of the genus are given as fungal parasites on *Thelotrema*, etc., but they are generally considered as lichens incidentally growing over other lichens, **9**, 97-8; **55**, 19-20; **31**, 45; **42**, 256.]
- [**S. bryophila** Wats. **74**, i, 130; **11**, 109; **14**, 74; **v**, 265. Collected near Llanberis on *Sphaerophorus melanocarpus* (*compressus*) and neighbouring liverworts. Entirely independent research by Abbé Grelet on a specimen, found on a liverwort collected by S. M. Macvicar in west Inverness during 1903, resulted in the description of *Stenocybe major* var. *macvicari* (**12**) which was included amongst the fungi. The author later acknowledged the priority of the name *bryophila*.]

PHACIDIINEAE

STICTIDACEAE

- Stegia vermicularis** (Arn.) Keissl., *Nesolechia* Arn. **23**, 255. This and other parasites on *Cerania vermicularis* have been described as 'fruits' of the host. The apothecia form galls on the thallus, are pale, flat or convex, immarginate, 100 μ diam. The asci are cylindric or cylindric-clavate, about 70 μ long and about 7 μ broad in the broadest part, with 8 simple, hyaline, \pm uniseriate, elliptical spores about 5-11 \times 3-5 μ . The paraphyses are thread-like, discrete, simple, rounded at apices; epithecium absent, thecium hyaline and hypothecium yellowish or pale brownish, I-. On Cader Idris *leg.* Watson apud Keissler in *Ann. Naturh. Mus. Wien*, xxxviii (1925), 163.
- [**Xylographa**. The following species are included as fungi by Ramsbottom in **51**, 380. They are included as lichens by A. L. Smith (**57**, 245-7) and other British lichenologists.]

- [*X. parallela* (Ach.) Fr. in 41, iv, 64; 8, 95; 31, 391; *Stictis* Fr. in. 61, 213; *X. abietina* (Pers.) Zahl. 83 (1923).]
- [*X. laricicola* Nyl. in 10, iii, 128; 31, 391.]
- [*X. scaphoidea* Stirt. in 14, iii, 36; 31, 391; *X. parallela* var. *pallens* Nyl. in 57, 246.]
- [*X. spilomatica* (Anzi) Th. Fr. *Agyrium* Anzi in *Comm. Soc. Critt. Ital.* II, 20; ? *X. minutula* Krb. Par. 276.]
- [*Odontotrema*. This genus was included in the lichens by Crombie 9, 10. The species put under this genus in Leighton's *Lichen Flora* occur on wood, have very indistinct thalli and are better included in fungi. The following have been given as British plants.]
- [*O. firmatum* Nyl. in 20 (1882), 276.]
- [*O. longius* Nyl. in 31, 389 and 51, 380.]
- [*O. majus* Leight. 31, 390. Spores $19-21 \times 7.5-8.5 \mu$.]
- [*O. minus* Nyl. in 31, 390; 20 (1882), 276. Spores $12-14 \times 5 \mu$.]
- [*Melittosporium lichenicolum* (Mont.) Mass. 41, iv, 88; 51, 380. This name has been given to the form of *Diploschistes scruposus* which occurs on the squamules of *Cladonia* and therefore considered by Massee and others to be a lichen parasite. It is, however, a true lichen and many intermediate states between the typical lichen with a proper thallus and the athalline form on the *Cladonia* squamules may be traced. It is given as *Urceolaria scruposa* var. *bryophila* form *lichenicola* (Rich.) Harm. in Harmand, *Lich. France*, 1150; by Crombie in 14 (1891), 60 as *Lecanora scruposa* subsp. *bryophila* form *ecrustacea*; by A. L. Smith, 55, 383, under *Diploschisteia bryophilus* Zahl. and in Zahl. *Cat. Univ.* as *D. scruposus* var. *parasiticus* (Somm.) Zahl. 73, 298; 74, x, 147; 77, 66. Sometimes the spores in the athalline form are less developed than they are in neighbouring typical plants.]
- [*Schizoxylon corticola* (Fr.) Nyl., *Coniangium* Fr. is recorded as a lichen on old oaks near Lyndhurst by Leighton in 31, 350. This species is not given by Massee, who states in 41, iv, 69, that *Schizoxylon* Pers. is not that of Leighton.]
- [*Melaspilea patersoni* Stirt. in 54, iv (1887), 29; 31, 437; 56, 225. It was collected from dead bark at Ben Brecht, v.c. 98, by Dr Paterson and is stated to be a discomycetous fungus, *Schizoxylon* species, in 57, 248.]

PYRENOMYCETES

PERISPORIALES

EUROTIACEAE

Eurotium herbariorum Link. ex Fr. For references see 4, 134. This is given in Keissler's list. It is not uncommon on imperfectly dried lichens, but rarely occurs on living specimens and is probably better considered as a saprophyte.

PERISPORIACEAE

Orbicula tartaricola (Nyl.) Cke. in 6, 926; 4, 137; 23, 267; *Sphaeria* Nyl. apud Leighton in 1 (1876), 408. On thallus of *Ochrolechia tartarea*, Cader Idris, Hengwrt, near Dolgelly.

[**Strigula babingtonii** Berk., *Eng. Bot. Suppl.* t. 2957 (1849); 28, 70; 78, 62; is included by Leighton, 31, 498 and Mudd, 42, 309, as a lichen. Zahlbruckner in 83 states that it is a fungus. Both Hariot (*J. Bot. Paris*, III, 285) and Mull.-Arg. (*Flora*, LXXIII, 200-1) had previously excluded it from the lichens as it had no algal cells. It is probably a perisporiale, but there is no reference to it in 4. Records from Sussex, Gloucestershire, Cambridge, Flint, Leicestershire, Yorkshire and Durham have been given. Description in 31 and 42.]

MICROTHYRIACEAE

Phragmothyrium cetrariicolum (Nyl.) Keissl. 23, 273; *Sphaeria* Nyl. in 14 (1874), 68; *Metasphaeria* Sacc. in 4, 178; *Psilosphaeria* Cke. in 14 and 62. On *Cetraria*, Braemar, in Scotland.

HYPOCREALES

[**Broomella leptogicola** (Cke. & Massee) Sacc. 23, 286; in 4, 176; *Hypocrea* Cke. & Mass. in 14, XIX, 86 and described from a specimen found on the thallus of a *Leptogium* on *Robinia* at Kew. Petch (45) gave a description of it, regarded it as the fructification of a lichen and discarded the name. Von Hohnel (*Ann. Myc.* xv (1917), 237) regarded it as insufficiently described and suggested that it might be a *Yatesula*. In the same journal (1918), 93, he gave the generic name of *Keissleria* to it.]

[**Calonectria leightonii** (Berk. & Br.) Sacc.; *Nectria* Berk. & Br. This name was given to a plant collected from Yorkshire by Leighton on a larch. Petch (45) states that the British specimen is a lichen and should certainly not be included with *N. leightonii* if the Cuban specimen is taken as type. He also rejects the plant in 46, 300; 4, 195.]

N. epicallopusma (Arn.) Sacc., *Cercidiospora* Arn. 23, 279, occurs on *Placidium* and has been doubtfully reported from Britain.

Nectria indigens Rehm, *Secoliga* Arn. 23, 278. A specimen with a pale red apothecium which was collected at Dartington, Devon, was placed here by Keissler.

N. lecanodes Ces. 23, 276; *Dialonectria* Berk. in 14, XII, 110; *Lasionectria* (Sacc.) Cke., Petch in 67 (XXI, 253) and 4, 198, is a semi-saprophyte on *Peltigera*. Recorded from King's Lynn and North Wootton, Norfolk, by Plowright and from Inverary by Boyd.

N. insidiosa Sacc.; *Hymenobia* Nyl.; *Psora aporea* Nyl., is given in 23, 279, as occurring on *Lecideas* in England.

Nectriella robergei (Mont. & Desm.) Weese. *Nectria* Mont. & Desm.; *N. lichenicola* Rehm; *N. peltigerae* Phil. & Plowr. 4, 200; 23, 281; 46, 270. Description in 46, 270. Occurs chiefly on *Peltigera* thalli. Recorded by Plowright from the King's Lynn district and from Forden by Vize.

Ciliomyces oropensis Hohn. *Sphaeria affinis* Grev. in 13; *Nectria affinis* Cke. in 62, sec. Petch (46), who puts the plant as *Paranectria affinis* (Grev.) Sacc., and states that it was found on *Ephebe lanata* at Appin by Carmichael. Description in 45, 201 and 46, 282. Other references given in 4, 201.

[**Thelocarpon epithallinum** Leight. 31, 439; 56, 345, is parasitic on the thallus of *Baeomyces rufus* at Stiperstones, Shropshire. It was included amongst the fungi by Rehm and Vouaux, the former regarding it as one of the Hypocreales, but Petch in 46 does not mention it. Zahlbruckner and other lichenologists, on account of the well-defined gonidial sheath of the perithecia, place it with the lichens, 23, 295.]

DOTHIDEALES

PHYLLACHORACEAE

Homostegia pelvetii (Hepp) Linds. in 39 (1867), 450, is referred by Keissler to *Conida fuscopurpurea*, 23, 303 and 4, 206.

H. piggotii (Berk. & Br.) Karst. 4, 206 and 23, 300; *Dothidea* Berk. & Br. in 1 (1852), 385; ? *D. homostegia* Linds. in 67, xxvii, 365 sec. 23, 301. On the thallus of *Parmelia* or other foliaceous lichen, Beddgelert, Capil Curig and Barmouth.

PSEUDOSPHERIALES

Adelococcus alpestris Theiss. & Syd. in 23, 309. The Ingleborough parasite mentioned in 75, iii, 206, may be this, but description too incomplete and the host was not *Acarospora*.

Mullerella atricola (Linds.) Sacc. in 23, 319; *Microthelia* Linds. 39 (1869), 554. Apothecia scattered, superficial, globose with somewhat flattened apices, small and dark. Ascus $50 \times 17\mu$, with many spores which are globose, dark brown and about 2μ diam. Keissler does not consider that the position of this plant is fully established. It was found on the thallus of *Lecanora atra* at Derryquin, Kerry.

M. haplotella (Nyl.) Arn. in 56, 345; *Endococcus* Nyl. in 5 (1868), 101; *Verrucaria* Leight. in 31, 495, is placed by Keissler under *Mullerella polyspora*, but has been considered distinct by some authors because the apothecia are darker coloured at maturity, 57, 386.

M. opegraphicola (Linds.) Zopf. Apparently given as a *Microthelia* collected by Carroll on *Opegrapha atra* at Aghada, Cork, by Linds. in 39 (1869), 543 and 549. Perithecia black, scattered, almost superficial, globose and flattened above, small. Ascus many-spored. Spores simple, round and brown sec. Keissler, $17 \times 8.5\mu$ (23, 319). Decidedly requires further examination before it can be accepted.

M. polyspora Hepp (1862) in 23, 315 (including *M. haplotella*); A. L. Smith in 67 (1908), 116; 4, 153. It occurs on *Arthonia*, *Bacidia*, *Lecidea*, *Opegrapha* and *Verrucaria*, and has been recorded from Jersey, Ben Lawers and Killarney. Perithecia scattered or \pm grouped, at first

immersed but later emergent, about $120-170\mu$ diam. Asci \pm cylindrical-obovate, $150 \times 50-60\mu$ many-spored. Spore simple, about $5-7 \times 2-3.5\mu$, pale brown, and sometimes with two guttulae. On various crustaceous lichens.

Rhagadostoma lichenicolum (DN.) Keissl. 23, 320; *Bertia* DN. 4, 157; *Sphaeria* Karst. in 14 (1873), 156; *Psilosphaeria* Cke. & Plow. 14 (1879), 85; 62, 389; ? *Microthelia solorinaria* Linds. in 50 (1869), 349; *Diplodina solorinaria* Vouaux, 71. Crombie, in 8, 280, states that the parasitic fungus, *Sphaeria lichenicola* DN., is occasionally seen on the thallus of *Solorina crocea*, a rare lichen, though locally abundant on the summits of some of the Grampians.

MYRIANGALES

[**Myriangium duriaci** Mont. & Berk. 4, 207; 75, 1; 77, 93. This has been included in lichens by Leighton (31, 37), Crombie (9, 15) and Taylor (as *Collema glomerulosum* Tayl.) in 11, 2, 108.]

SPHAERIALES

SPHAERELLACEAE

Guignardia corniculata (Wallr.) Keissl. in 23, 348 (as a doubtful species); *Obryzum* Wallr. in 56, 266; 77, 92; *Verrucaria* Leight. 31, 497; *Sphaerulina* Vouaux, 71 (1913), 36. On various species of *Leptogium* and recorded from five botanical counties. Description by A. L. Smith in 57, 289. The inclusion of this species by Saccardo in *Metasphaeria* (1905) and by Vouaux in *Sphaerulina* (1913) requires some explanation, as both these genera have septate spores. Apparently the spores in the apothecia of the host were taken instead of those of the parasite. Both Nylander (1858-60) and Leighton had difficulties in regard to this, and the latter gave the spores as 'obsoletely 7-septate'. A. L. Smith (1911) described the spores as 'simple with several guttulae'. Keissler, on account of this, puts the parasite under *Guignardia*.

G. fimbriatae Keissl. 23, 346; *Paralaestadia* Vain. 70, 1, 75 and 245. A specimen collected by R. Burn on *Gladonia* on Cader Idris. Its chief distinctions from other *Guignardia* species are its host and the negative coloration with iodine.

G. insularis (Mass.) Keissl., *Endocarpon* Massal. 23, 343; *Dermatocarpon insulare* Migula in 76, 1933 and 1938. Recorded from six vice-counties. In small insulated patches on calcareous rock over *Lecanora albescentis* and *Placodium*. For description see 76 (1933), 336. This species and the following (*psoromoides*) are given by Keissler under *Guignardia*, *ad interim*.

G. psoromoides (Borr.) Keissl. 23, 346; *Verrucaria* Borr. 18; *Endocarpon* Leight. 28, 13; ? *Laestadia* Vouaux, 56, 344; *Physalospora* Wint. 4, 147; 57, 385. On trunk of elm, Hurstpierpoint and Beeding, Sussex. Description in 42, 267. Spores given by Keissler as $12-14 \times 5\mu$.

- Sphaerulina dolichotera** (Nyl.) Vouaux, 71; 23; 57, 386; *Verrucaria* Leight. in 31, 497; *Obryzum* Nyl. in 56, 266. Parasitic on collemaceous lichens, Blair Atholl. Described in 57, 289.
- S. corniculata** Vouaux, 71 (1913), 36; *Obryzum* Wallr. 77, 92, is transferred by Keissler to *Guignardia*.
- S. endococcoidea** (Nyl.) Sacc. & D. Sacc. 71 (1913), 35; 23, 436; 57, 386; *Verrucaria* Nyl. in 31, 493; apud Carroll, 5; Lindsay, 50 (1869), 351; Crombie, 8, 116. A. L. Smith, in 56, 344, places *Verrucaria dubiella* Nyl. as a probable synonym of *V. endococcoidea*. Keissler states that if this is correct, though both are described by Nylander on the same page in the same *Flora*, *dubiella* precedes *endococcoidea* and therefore has priority, so that *Sphaerulina dubiella* is the correct designation. Parasitic on the thallus of *Rhizocarpon excentricum*, Ben Lawers, also from Killarney and near Dublin. For description see 31, 493.
- S. dubiella** (Nyl.) Keissl. 23, 437; *Verrucaria* in 31, 477, where a description is given; *Pharcidia* ? *dubiella* A. L. Sm. 56, 344; 4, 171. See *Sphaerulina endococcoidea*. Recorded by Carroll in 20 (1866), 25, from Ben Lawers. Nylander considered it to be a 'species beni distincta'.
- Mycosphaerella cookei** (Linds.) Sacc. & D. Sacc. 23, 381; *Microthelia* Linds. 39 (1869), 537, Pl. XXIII, f. 29. Perithecia black, scattered under the thicker and whitish parts of the thallus of the host (*Lecanora crenulata*). Ascus many-spored, clavate becoming irregularly swollen, $47 \times 11.5 \mu$. Paraphysoid hyphae ? in a slimy mass. Spores longly ellipsoid, hyaline, 1-septate (often simple), $5.5 \times 2.25 \mu$. Found by Cooke on thallus of *L. crenulata* in England.
- [**Astrothelium parmularia** (Berk.) Leight. 31, 499; *Sphaeria* Berk. in Hook. *Journ.* (1851), 19. This is given and described as a lichen by Leighton, with locality New Forest. A. L. Smith states that it is a fungus, 56, 263. It is given as *Valsaria parmularia* (Berk.) Sacc. in 4, 175.]
- Discothecium acervatum** (Stirt.) A. L. Sm. 57, 387, with description; *Lophothelium* Stirt. 54 (1887), 37; 56, 265. From Ben Lawers and Killin, on the squamules of *Stereocaulon condensatum*, causing them to be distorted. Keissler considers that the description is incomplete. The paraphyses are stated to be 'rather sparse' in 56, but in 57 they are given as 'crowded'. The latter description is probably correct.
- D. gemmiferum** (Tayl.) Vouaux, 71 (1913), 46; 23, 385; 57; 44 (1935), 235; 75, II, III and IV; 78, 62; 77, 93; *Verrucaria* Tayl. in 11, II, 95, and 28, 47 and 75; *Microthelia* Mudd, 42, 306; *Tichothecium* Krb. in 4, 175; 56, 343; *Verrucaria rugulosa* Borr. 28, 47; *Microthelia* Mudd, 42, 306; *Verrucaria larbalestierii* Leight. 68 (1877), 242; ? *V. melaspora* Tayl. in Lond. *J. Bot.* (1847), 153; *Endococcus gemmiferus* Nyl. and *E. rugulosus* Nyl. in 8, 122. Common and widely distributed on crustaceous lichens. As type Keissler takes those with medium spores ($8-12 \times 4-6 \mu$); var. *brachysporum* those with small spores ($6-7 \times 5-6 \mu$); var. *calcaricolum* has large spores ($13-22 \times 6-8 \mu$) whilst var. *physciolum* differs by the formation of galls.

- Var. **brachysporum** Vouaux, 71; *Tichothecium gemmiferum* var. Zopf, etc., 23, 391. On various Lecideas and other crustaceous lichens, but few British records.
- Var. **calcaricolum** (Mudd) Keissl. 23, 389; 77, 93. *Discothecium calcaricolum* Vouaux, 71 (1913), 49; *Microthelia* Mudd, 42, 306; *Verrucaria*, 31, 495; *Tichothecium*, 4, 175; *Verrucaria perpusilla* Leight. 31, 496; 77, 93; *Tichothecium* (Nyl.) Arn. in 4, 175; *Endococcus* Nyl. in 31, 496; *Verrucaria fumosaria* Leight. 68 (1876), 239. *Endococcus calcareus* Nyl. in 8, 122. Has been recorded from many British localities.
- Var. **physciolum** (Nyl.) Keissl. *Mycoporum* Nyl. 23, 392; *Discothecium physciolum* Vouaux, 71 (1913), 48. *Microthelia parietinaria* Linds. in 69 (1869), 541. On *Xanthoria parietina*.
- D. squamarioides** (Mudd) Keissl. 23, 403; 78, 62; *Sphaeria* Mudd, 42, 130; *Tichothecium* Wint. in 4, 175; *Sorothelia* Zopf in 57, 385. Description of this fungus parasitic on Harriman's Teesdale specimen of *Squamaria gelida* is given in 42, 130. The perithecia are 150–250 μ diam. and the spores 9–25 \times 5–9 μ . It occurs on *Phlyctis* at Cleeve, v.c. 6.
- D. stereocaulicolum** (Linds.) Vouaux, 71 (1913), 57; 57, 387; *Microthelia* Linds. 69 (1869), 537. On the podetia of *Stereocaulon* in Glen Derrie, Braemar, v.c. 92. It is insufficiently described *sec.* Keissler. It produces deformations on the podetia forming gall-like warts. Perithecia single or two in each wart, only emergent at apices. Ascus elliptic with distinct stalk, usually thick-walled, 60 \times 17 μ . Paraphyses (? periphysal hyphae) indistinct. Spores 8-nae, obovate, biseriate, 1-septate, hyaline to olive or brown, 12.5 \times 8 μ .
- D. stigma** (Krb.) Zopf; *Tichothecium* Krb. 23, 393, 71 (1913), 52 and 68 (1869), 367. Perithecia scattered but numerous, slightly bleaching or shading the host, quite sunk, ovate or top-shaped, slightly convex 120–300 μ long by 240 μ broad, black. Ascus fusiform, slightly ventricose, above rounded and usually with a thick wall, below forming a thick foot. Paraphyses present. Paraphyses (? periphysoid hyphae) soon disappearing. Spores 8-nae, biseriate, 1-septate, not or little constricted in the middle, 13–20 \times 4.5–8 μ , pale olive to sooty brown. Hym. gel. red or blue or negative with iodine. On lecideoid lichens, recorded from Llanberis, v.c. 49, and Glen Dole, v.c. 90.
- D. vermicularium** (Linds.) Vouaux, 71 (1913); *Microthelia* Linds. in 68 (1869), 319 and 69 (1859), 144 *sec.* 23, 407. On the thallus of *Cerania vermicularis*. Perithecia numerous, sunk, pressed together or flattened, very small, black (when moistened brown) with brown cells forming the tissue. Asci irregularly massed, obovate, unstalked, with thick walls at their apices. Spores longly ovate, brown, 8-nae, 1-septate with a strong constriction, about 8–11 \times 3–4 μ .
- Tichothecium cerinarium** (Mudd) Berl. & Vogl. 4, 175; 56, 344; 57, 388; *Sphaeria* Mudd, 42, 136, is a doubtful plant which is probably better included in *T. pygmaeum* var. *erraticum* according to Keissler. Collected by Mudd from Ayton in v.c. 62.

T. pygmaeum Krb. Massee in **14**, xvii (1888), **4**, 175; A. L. Smith & Rea (inclusive of var. *ventosicolum*), **60**; **56**, 343; **57**, 387; **75** (1942); **77**, 93; **78**, 62; *Microthelia* Krb. **23**, 119; *M. ventosicola* Mudd, **42**, 307; *Verrucaria* Leight. **31**, 495; *Sphaeria ventosaria* Linds. **69** (1866), 439; *Endococcus ventosus* Nyl. **8**, 123. For description see **23**, 411 and **31**, 495-6. *E. thalamitus* Nyl. in Crombie, *J. Linn. Soc.* (1887), 217 refers to a foreign specimen. Keissler gives two varieties; var. *ecatonosporum* with perithecia up to 400 μ diam., asci to 95 \times 23 μ and spores to 12 \times 6 μ ; var. *erraticum* with perithecia 40-90 μ , asci 30-50 μ and spores broadly ellipsoid, 3.5-6 \times 2-3 μ ; the type being intermediate in the size of these organs, perithecia 50-400 μ , asci 45-95 \times 15-23 μ , and spores 4-12 \times 2-6 μ .

Var. **ecatonosporum** (Anzi) Wint., *Microthelia* Anzi in **23**, 414.

Var. **erraticum** (Massal.) Vouaux, **71**; **23**; **75** (1942); **77**, 93; **25**, 432; *Endococcus* Nyl. in **8**, 122; subsp. *microphorus* Nyl. apud Crombie in **20** (1882), 276; *Verrucaria* Leight. **31**, 496, which see for description. Recorded from many localities.

Var. **ventosicolum** (Mudd) Wint. in **4**, 175, is not considered distinct by Keissler.

Pharcidia aggregata (Mudd) Vouaux, **71** (1912), 252; **23**, 372; **57**, 386; **25**, 341; *Thelidium* Mudd, **42**, 289; **38** (1869), 346; **57**, 386. On *Aspicilia calcarea*, Barclay's Rock leg. Adm. Jones. On *Pertusaria lactea* on rock above Llanarmon in v.c. 50. For description see **42**, 298.

P. allogena (Nyl.) Sacc. **23**, 362; **57**, 386; *Verrucaria* Nyl. **31**, 492; *Arthopyrenia* Arn. **56**, 324 and **57**, 356 (which see for description); *Verrucaria epidermidis* var. apud Carroll in **5** (1886), 25. On *Rhizocarpon* in Ireland (Kylemore Castle) and on Ben Lawers. Form **innata** (Nyl.) Keissl. **23**, 363. *Verrucaria innata* Nyl. in Carroll **20** (1866), 25; **31**, 494; *Pharcidia* Sacc. & D. Sacc.; *P. innatula* Zopf sec. **23**; Vouaux in **57**, 386; *Verrucaria* in Hue *Add.* 301. For description see **31**, 494. On Ben Lawers, parasitic on the same thallus as *Pleospora hookeri*.

? **P. consociata** (Nyl.) A. L. Sm. *Verrucaria* Nyl. ex Carroll in **20** (1865), 293. A very minute, unsatisfactory plant 'apparently parasitic on an alien thallus. The spores are 1-septate and broader at one end', **57**, 386. On the summit of Ben Lawers.

P. dispersa (Lahm) Wint. **71** (1912), 234; **23**, 354; **75**, III (1942); *Epicymatia thallina* (Cke.) Sacc. in **4**, 176; *Sphaerella* Cke. **6**, 372; *Pharcidia crombii* Sacc. & D. Sacc. in **57**, 386; *Endocarpon* Mudd, **42**, 36; *Pharcidia frigida* (Sacc.) Vouaux in **23** (also included by Keissler as it is like *P. crombii* and also occurs on *Thamnolia*), *Pharcidia hageniae* Rehm in **14**, xviii, 79. *Verrucaria conspurcans* Leight. in **1** (1868), 29, with synonyms *Arthopyrenia* and *Pharcidia*, refers to a foreign specimen and is included by Keissler. For description see **42**, **23**, **71** and **10** (1869), 233. Records few, Eastbourne, Talsarnau, Penmanshiel, Craig Rossie and near Taunton, but the fungus, which occurs on the thalli of many lichens, is probably frequent.

P. dubiella (Nyl.) A. L. Sm. **56**, 344; **4**, 171, is given by Keissler under *Sphaerulina*, **23**, 437 (see *S. endococcoidea*).

- P. epicymatia** (Wallr.) Wint. 23, 373; 57, 386; 75, I and III; 78, 62; *Sphaeria* Wallr. *Pharcidia congesta* Krb. as synonym in 57; 50 (1869), 343; *Epicymatia vulgaris* Fkl. 4, 176; *Sphaerella* B. & Br. in 6; *Sphaeria apotheciorum* Massal. in 6, 872. Described in 23, 71, etc. Common on the apothecia of *Lecanora* species and recorded from many British vice-counties.
- P. gyrophorarum** (Arn.) Zopf, *Arthopyrenia* Arn.; *Pharcidia gyrophorae* (Arn.) Zopf, *Arthopyrenia* Arn. in 23, 379. Keissler takes the former name as having priority. The species occurs on *Gyrophora*. Sec. A. L. Smith in 57, 334, a minute fungus on *Dermatocarpon squamules* from Ben Lawers agrees, except in the host, with *Thelidium superpositum* (*Pharcidia superposita*), but is also akin to *P. gyrophorae*.
- P. microspila** (Krb.) Wint. in 57, 386; 75, IV; 78, 62; 25, 421-2; *Arthopyrenia* Krb. in 56, 322; 57, 353; 75, III; *A. rhyponota* Mudd, 42, 303; *Verrucaria rhyponota* Borr. (non Ach.) in 17, 11; 39, 28; 57, 353; 61, 154. Description in 57, 353. It occurs on or near the thallus of *Graphis* and has been recorded from five English, three Scottish and six Irish botanical vice-counties. Another species of *Arthopyrenia*, *A. spilobola* (Nyl.) A. L. Sm. 57, 354, may also have to be included with fungi. Knight's specimen from Keswick and my own from Killarney have very few or no algal cells. *Arthopyrenia? colleta* A. L. Sm. 57, 356; *Verrucaria* Stirt. 31, 468 also is probably a fungus which may be a *Pharcidia*.
- P. punctilla** Wint. 23, 378; 71 (1912), 241. Keissler considers this to be a *Pharcidia*, though it is rather insufficiently described. It may be the same fungus as *Didymella coarctatae* B. de Lesdain, 34 (1907), 695. Both Vouaux and Keissler agree in placing Lesdain's species as a probable *Pharcidia*. Perithecia scattered, very small, punctiform, semi-globosely emergent, dark brown. Ascus from a wide-bellied base to smaller above, sessile with 8 irregularly ordinated spores, $30-40 \times 14-16\mu$. Spores longly clavate, 1-septate, hyaline, $14-18 \times 3.5\mu$ with rounded ends and at septum not or very slightly constricted. On *Biatorina cyrtella*, Broomfield, near Taunton, Somerset.
- P. superposita** (Nyl.) Sacc. & D. Sacc. 23, 368; 71 (1912), 248; 57, 386; *Verrucaria* Nyl. in 31, 494; 20 (1866), 25; *Thelidium* A. L. Sm. in 56, 300. Found by Carroll on *Polyblastia theleodes* on Ben Lawers. Described as *Thelidium superpositum* in 57, 328.
- P.? triphractoides** (Nyl.) A. L. Sm. 56, 344; 4, 171; *Endococcus* Nyl. ex Crombie, 14 (1874), 24; *Verrucaria* Leight. 31, 497, is given by Keissler as synonymous with *Phaespora parasitica*.
- Epicymatia thallophila** (Cke.) Sacc. in 54 (1911), 38; *Sphaeria* Cke. in 6, 872; *Sphaerella* Cke. in 14, XVIII, 79; Masee, 14, XIX, 44; *Psilosphaeria* Stevenson in 62, 388. On lichens, Scotland. The position of this is doubtful. It is given by Cooke in 6, 872 as 'scattered or gregarious, semi-immersed in the lichen thallus; perithecia subglobose, carbonaceous, papillate, pierced; asci cylindrical; sporidia uniseriate, elliptical, uniseptate, not constricted, hyaline, at length pale greenish yellow, .0004 in. long. On the thallus of *Lecanora subfusca*, Glenshee,

Aug. 1856. Dr W. Lindsay. It is not improbable that this is a naked *Sphaeria* springing from the wood beneath and perforating the thin lichen thallus. A single small specimen was all that we have seen and that was insufficient to satisfy us on this point.' Wheldon, in 54 (1911), 38, states 'this is evidently not the case, as we have found the perithecia both on the thallus and on the apothecia of the lichen and from one to fourteen perithecia have been observed on a single apothecium'. It has been considered as synonymous with *Pharcidia dispersa*, and the Eastbourne specimen (at one time referred to it) is so, but from Wheldon's reference to the occurrence of the parasite on the apothecia of the Loch Rannock plant I am inclined to place his plant under *Pharcidia epicymatia* though I have not been able to examine the specimen.

Phaeospora caninae (Ph. & Plow.) Vouaux, 71 (1913), 74; 23, 428; *Sphaeria* Ph. & Plow. 14 (1877), 27; *Psilosphaeria* Cke. & Plow. 14 (1879); *Heptameria* Cke. 14, xviii, 31. Given in 4, 182, as occurring on *Peltigera canina* at Dunsley. Probably Dursley in Gloucester is the correct locality, as Joshua collected the material. It has also been recorded for Killin, v.c. 88.

P. epicallospisma (Wedd.) Fl. Bad.; *Verrucaria* Wedd. 23, 428. Perithecia semi-immersed, globose or semi-globose with gaping ostiole, quite black, 200–250 μ diam. Ascus probably 8-spored. Spores brown, 3-septate, elliptical or \pm ovate, 24–36 \times 8–12 μ . Hymenium without paraphyses and not coloured with iodine. Usually occurs on *Caloplaca*. The only British record is near Taunton where it occurred on *Placidium murorum*.

P. exoriens (Stirt.) A. L. Sm. 57, 388; *Endococcus* Stirt. 54 (1880), 220; *Pyrenococcus* Wheld. & Wils. 79, 69; 55, 482 (with description). A. L. Smith considers this to be worthy of segregation from *Phaeospora parasitica*, but Keissler does not mention it. It was found at Kinloch Rannock, v.c. 88, on *Pannaria*.

P. heteraizans Arn. 23, 427; 57, 338; *Verrucaria* Leight. 31, 493; *V. marginacea* in Leight. 28, 62 and Pl. XXVI, 3. Described in 31, 493. Collected by Borrer on *V. submersa* in Sussex. *Microthelia dissepta* A. L. Sm. 56, 352; 57, 364; 25, 426; *Verrucaria* Nyl. in 14 (1877), 107; 31, 480 is now included under *Phaeospora heteraizans*. It was collected by Larbalestier on mica-schist rocks, Doughruagh Mts., Galway, and by A. L. Smith on *Rhizocarpon confervoides* at Doogea in Achill. Nylander thought that the plant was probably a parasite.

P. parasitica (Lonnr.) Arn. 23, 421; *Verrucaria peripherica* Tayl. 11, 11, 97; *Endococcus* Cromb. 8; *Microthelia* Mudd, 42, 308; *Phaeospora* Arn.; *Verrucaria rimosicola* Leight. 31, 496; 69 (1869), 367; *Microthelia*, 42, 308; *Tichothecium* Arn. in 56, 344; *Phaeospora* Zopf in 57; 78, 62; 79, 93; 25, 402; *Pharcidia triphractoides* (Nyl.) A. L. Sm. 56, 344; 4, 171; *Endococcus* Cromb. 14 (1874), 24; *Microthelia petraicola* Linds. sec. Vouaux, 71 (1913), 69; *M. dispersa* form *octospora* Wats. 74 (1925), 132; *Verrucaria gagei* Deakin non Borr. 1 (1854), 37; *V. advenula* Nyl. with

other references in 57, 388; 20 (1867), 260; 50 (1869), 351; 8, 121. For description see *V. rimosicola* in 31, 496. On lecanoroid and lecideoid lichens, common and widely distributed.

Var. *dzieduszykii* (Bob.) Keissl. Differs from the type in having only two spores in the ascus. It was described as *Microthelia dispersa* by A. L. Smith in 57, 331, from a specimen collected by Joshua at Sapperton in Gloucestershire. A specimen collected by Knight at Cheltenham agreed, both externally and internally, with *M. dispersa*, except that the ascus contained 8 spores, was provisionally referred to form *octospora* in 74 (1925), 132, and given as *M. dispersa* form *octospora* Wats. in A. L. Sm. 57, 364. Keissler considered that my plant was typical *Phaeospora parasitica* and that Miss Smith's was the above-mentioned variety. *Microthelia exerrans* A. L. Sm. 56, 332; 57, 364; 79, 72; *Endococcus* Nyl. apud Cromb. in 14 (1880), 114 and 20 (1882), 276. On quartzose stones at the summit of Cairn Gowar, Blair Atholl. This was considered by Crombie as quite possibly a fungus. So far as the rather incomplete description warrants, it seems to belong to *Phaeospora* and may be a form of the variable *P. parasitica*, though the spores are small even for this.

P. parmeliarum (Ph. & Plow.) Vouaux, 71 (1913), 75; 23, 430; *Sphaeria* Ph. & Plow. in 48 (1876), 124; *Psilosphaeria* Cke. & Plow., *Melanomma* Cke., *Heptameria* Cke., *Leptophaeria* Sacc. in 4, 185. On *Parmelia*, Dolgelly.

P. superspersa Arn. in 23, 427. On the thallus of *Lecidea macrocarpa*, Killarney. Perithecia scattered or aggregated, immersed at first, but later, with the blunt apex showing, broadly ellipsoid or ovoid, 60–200 μ diam., dark. Asci cylindrical or somewhat swollen in the middle, shortly stalked, 85–90 \times 10–14.5 μ . Spores 4-nae (seldom 5–6-nae) usually with 3 septa (seldom with less or more) brown, \pm ellipsoid, often pear- or egg-shaped (seldom fusiform or clavate), straight or little curved, about 16–21 \times 7–12.5 μ . No definite coloration with iodine.

P. vesicularia (Linds.) Arn., *Microthelia* Linds. 69 (1869), 543 and Pl. XXIV sec. Vouaux, 71 (1913), 126. Keissler considers that this is a doubtful species which, on account of the many-spored ascus, cannot belong to *Phaeospora*, 23, 431. Perithecia aggregated, \pm superficial, black. Ascus many-spored, (?) 68.5 \times 21 μ . Spores 1–3-septate, usually 3-septate, fusiform or ovate, brown, 8–12 \times 4 μ . On *Pertusaria*, Balthaycock woods, v.c. 89.

Merismatium lopadii (Anzi) Zopf, *Celidium* Anzi in 23, 441. Keissler considers that *Polyblastia nigritella* Arn. (A. L. Sm. in 56, 305), *Verrucaria* Nyl. in *Flora* (1865), 357, *Merismatium* Vouaux (1913), 77 to be identical. If this is so, *Merismatium nigritellum* (Nyl.) Vouaux seems the correct designation, as Nylander's specific name dates from 1865 whilst Anzi's specific name of *lopadii* in *Atti. Soc. Ital. Sci. Nat.* dates from 1868. For description, etc., see Carroll in 20 (1866), 25, Crombie, 8, 110, Leighton, 30, 466 and 31, 497 and A. L. Smith, 57, 334. The only British locality given is Ben Lawers, where it was with *Dermato-carpon cinereum*. A. L. Smith, in 57, 334, states that *Polyblastia gothica*

Th. Fr. is similar if not identical. This was collected by Leighton at Shrewsbury on decaying humus and larch poles, was at first given as *Verrucaria pituphloia* Leight. in 30, 458 and later as *V. gothica* Leight. in 31, 490. Th. Fries recognized that this species resembled a *Sphaeria*.

[**Leptorhaphis epidermidis** (Ach.) Th. Fr. in 56, 330, etc. The thallus is very thin or often practically absent. It has been included amongst the fungi by Wainio (*Lich. Brazil*, 13) and others (73, 316), but is definitely placed with the lichens by most lichenologists. Our other species of *Leptorhaphis*, *L. carrollii* A. L. Sm. 57, 362, may be considered similarly. It occurs in other localities besides 'the only locality' given by A. L. Smith.]

PLEOSPORAE

PLEOSPORACEAE

Didymella collemata Vouaux, *Cercidiospora* species Stein. in 71 (1913), 97. Keissler does not mention this in 23. On the thallus of *Collema* on rocks in Goblin Combe, Somerset, v.c. 6. Similar to *Didymella pulposi* but with rather larger perithecia, asci and spores, the latter 6-8-nae and thinning out at one or both ends, 73, 316.

D. epipolytropa (Mudd) Berl. & Vogl. 4, 165; 23, 453; 57, 389; 78, 62; 75 (1939), 515; *Thelidium* Mudd, 42, 298; *Didymosphaeria* Wint. in 56, 344; *Verrucaria* Cromb. 8, 121; 31, 494; *Arthopyrenia verrucosaria* Linds. 50 (1869), 349. On *Lecanora polytropa*, *Aspicilia verrucosa* and other crustaceous lichens in v.c. 19, 47, 48, 62, 88 and 96. For description see 31, 42, 56 and 57.

D. pulposi (Zopf) Vouaux, 71 (1913); 78, 62; *Didymosphaeria* Zopf in 4, 174; 73, 316; 77, 93. On *Collema* and *Leptogium*. As yet only recorded from three botanical counties, but probably much more frequent. Perithecia \pm immersed in warts on the thallus of the host, 100-200 μ diam. Ascus clavate, about 45-75 \times 10-17 μ , 4-6-spored. Spores longly ovate, colourless, with obtuse ends, about 13-20 \times 4.5-7.5 μ .

D. sphinctrinoides Berl. & Vogl. in 23, 458 and 71 (1913), 91. Perithecia dark brown, 150-250 μ with a small ostiole. Ascus 70-100 \times 10-13.5 μ . Spores 8-nae, 18-22 \times 6-7.5 μ . Paraphyses numerous and longer than asci. On *Verrucaria* near Wiveliscombe, Somerset. Because of its host this would have been included by Vouaux under var. *verrucariae* (Zopf) Vouaux. Six varieties are given by Vouaux (often on account of host), but Keissler gives all of them as synonyms of the type.

Metasphaeria cetraricola (Nyl.) Sacc. 4, 178 is placed by Keissler (23, 273), under *Phragmothyrus*.

M. tartarina (Nyl.) Keissl., *Verrucaria* Nyl. in 23, 487, depends for its inclusion on two uncertainties. Keissler gives *V. campsteriana* Linds. in 68, xxvii, 343 as a probable synonym, and Lindsay's reference apparently refers only to a foreign specimen.

Didymosphaeria gelidaria (Mudd) A. L. Sm. 23, 480; 56, 344; 78, 62; *Sphaeria* Mudd, 42, 130; *Tichothecium* Berl. & Vogl. in Masee, 14, xvii; 4, 175. Collected by Harriman on the thallus of *Squamaria gelida*

in Teesdale and described by Mudd (spores are given by Keissler as mostly 4-nae and $10 \times 6.5 \mu$).

- D. melanospora** Hepp is given by Vainio in 70, 1, 151 as equivalent to *Microthelia atomaria* Koerb. This is given as a rare lichen by A. L. Smith in 56, 331 and 57, 363. It has been recorded from Cricklease near Chard in v.c. 5 and Kylemore in Ireland, v.c. 16.
- D. microstictica** Wint. 23, 475; 56, 344; 4, 174; *Verrucaria* Leight. 30, 461; *Endocarpon* Leight. 29, no. 317, without description; *Acarospora cervina* var. *microsticta* Mudd, 42, 159. For description see 31, 493. On *Acarospora* at Barmouth.
- D. micula** (Flot.) Vain. is given by Vainio in 70, 1, 146 and 254 as equivalent to *Microthelia micula* (Flot.) Koerb. given by A. L. Smith in 56, 331 and 57, 363 as a lichen. It occurs in 20 British and Irish vice-counties. No definite trentepohlioid algal cells were seen in a Cwm Bychan (v.c. 48) specimen, but a few were noticed in a specimen from Ben Doran (v.c. 98).
- Leptosphaeria baeomycearia** (Linds.) Sacc. & Trott, 71 (1913); *Microthelia* Linds. 39 (1869), 541 or 554. On *Baeomyces rufus* in Britain sec. 23, 501. Keissler considers that the description is so incomplete that it is better discarded, though, if it is referred to *Leptosphaeria neottizans*, the specific name is earlier.
- L. crozalzii** (Sacc.) Vouaux, 71 (1913), 120 and 23, 498. *Verrucaria tartaricola* Linds. 38 (1869), 351 is given by Keissler as a probable synonym, but the only reference found referred to a Greenland plant on *Ochrolechia tartarea*.
- L. leucomelaria** (Mudd) Vouaux, 71 (1913), 121 and 23, 494; *Sphaeria* Mudd, 42, 105; *Tichothecium* Berl. & Vogl. in 4, 175. On thallus of *Anaptychia ciliaris* and *A. leucomelaena*.
- L. neottizans** (Leight.) Zopf in 23, 494; *Verrucaria* Leight. 68 (1878), 239; *Didymosphaeria* A. L. Sm. 56, 344; 4, 174. On thallus of *Baeomyces*, Fishguard. For description see 31, 497. Vouaux has suggested that *Microthelia baeomycearia* Linds. 39 (1869), 541 or 554, might be included here. If so, this specific name has priority.
- L. pycnostigma** (Nyl.) Sacc. & D. Sacc., *Verrucaria* Nyl. in 23, 495. Keissler considers that *Microthelia baeomycearia* Linds. might be referable here.
- [*Massaria scoriadea* Cke. in 14 (1889), 93; *Sphaeria* Fr. in 56, 345; *Massariella* Sacc. in 4, 174 (with other references). It was given as the lichen *Verrucaria conferta* Tayl. in 11, 185; 28, 39.]
- Pleospora ? addubitans** (Stirt.) A. L. Sm. 57, 328 and 389; *Verrucaria* Stirt. 54 (1880), 220; *Polyblastia* Wheld. & Wils. 79, 71; 55, 483 (with description). On decaying wood, Kinloch Rannoch, v.c. 88.
- P. hookeri** (Borr.) Keissl. 23, 503; *Verrucaria* Borr., *Dacampia* Massal. in 56, 273; 75 (1935), 520; *Sphaeria* Nyl. in 39 (1869), 548; ? *Verrucaria arctata* Stirt. 65 (1879), 320; *Lecidea nigropunctata* Hook. *Fl. Scot.* 2nd ed. sec. Menzie in herb. 75 (1935), 520; *L. hookeri* Schaer. apud 8, 88 and 30, 309; *L. sphaerica* Schaer. appears to be the oldest name sec. Keissler. On the summit of Ben Lawers. For description see 57, 296. This has

been considered as (1) a lichen with its own thallus, (2) an apothecium of a fungus parasitic on a lichen thallus. For many years it has been included amongst the lichens, but Keissler and Zahlbruckner take the latter view.

Neolamya peltigeræ (Mont.) Theiss. & Syd., *Sphaeria* Mont. 23, 519. On thallus of *Peltigera rufescens*, Pont Nedd Fechan, v.c. 41. Perithecia scattered, immersed, globoso-ovate, deep black, apparently without ostiole, ringed round by the freed layer of the cortex of the host thallus. Ascus clavate or longly cylindrical, to 110μ long with many spores which are acicular, straight or slightly bent, $50-100 \times 2-3\mu$. with many oil-drops.

FUNGI IMPERFECTI

SPHAEROPSIDALES

Ascochyta lecanoræ (Vouaux) Keissl. 23, 574. An unnamed plant mentioned by Lindsay in 68, xxviii, 228 as a pycnidium is considered as probably referable here, 23, 575.

Dendrophoma alcicorniaria (Linds.) Vouaux in 57, 390; *Microthelia* Linds. 39 (1895), 161. On under-surfaces of squamules of *Cladonia foliacea*. *Dendrophoma podetiiicola* Keissl. in A. L. Sm. 67 (1910), 282, but Keissler (23, 551) discards this specific name as *alcicorniaria* has priority.

Diplodina lichenodes A. L. Sm. 67 (1910), 283 is not given by Keissler. It was found on a lichen thallus on walnut bark at Writtle, Essex, and collected by Piggott.

D. solorinaria Vouaux, 71 (1914), 283; *Microthelia* Linds. in 38 (1869), 349; 57, 390. Keissler puts this as probably *Rhagadostoma lichenicolum* with the *Pseudosphaeriales*, 23, 320.

D. vouaxi B. de Lesd. apud 71 (1914), 288; 23, 572-3. Possibly the unnamed parasite on the thallus of *Lecanora albella* given by Lindsay in *Observations lichen. Microfungi*, p. 37, and the pycnidia which Lindsay, in 69 (1872), 284, gives on *Enterographa crassa* may be placed here *sec.* Vouaux.

Libbertella peltigeræ (Lib.) Keissl. 23, 582; *Zythia* Lib. apud Cke. in 14 (1880), 83. On podetia of *Cladonia*, but no reference to a British locality.

Lichenoconium imbricariæ (Allesch) Keissl. *Coniothyrium* All. in 23, 564; ? *Microthelia cargiliana* Linds. in 69 (1866), 439 and Pl. XXX, but Lindsay gives no British locality.

Phoma abietinæ Vouaux, 71 (1914), 547. On the thallus of *Lecanactis abietina*. This depends on a very incomplete description by Lindsay and is a very doubtful species (23, 589).

P. lecanoræ Vouaux, 71 (1914), 547; 32, 277; 33, 164; 23, 544. On apothecia of *Lecanora subfusca* (agg.), Taunton, v.c. 5, Blair Atholl, v.c. 89. It is probably frequent. According to Vouaux some of Lindsay's spermogonia may belong to it. 'Perithecia' dark, \pm immersed, minute, $80-150\mu$ diam., somewhat lens-shaped. Conidia about $3-7 \times 1.5-2.5\mu$, ellipsoid, hyaline, borne on longer carriers.

P. uncialicola (Zopf) Vouaux, 71 (1914), 198; *Phyllosticta* Zopf in Sacc. *Syll. fung.* 1 (1906), 245. *Abrothallus moorei* Linds. was included by Vouaux under this, but Keissler points out that Lindsay gave an ascus with spores to his species. See *A. moorei* on p. 312.

Vouauxiella lichenicola (Linds.) Petr. & Syd. 23, 565; *Torula* Linds. 39 (1868-9), 115 and 530 and Pl. XXIII; *Sirothecium* Keissl. in 71 (1914); 15, II, 133; 72, 82. Pycnidia loosely scattered, ovate, ellipsoid or almost round, mostly about 60-90 μ , their covers consisting almost entirely of the darkened and somewhat diminished cells of the host; conidiophore dark; conidia toruloid. On the thallus and apothecia of many lichens, chiefly Lecanoras. Apparently common, as it is recorded from many localities in v.c. 5, 11, 17, 64, 72, 81, 88, 92, 93, 98, 100; Ireland, 1-5.

MELANCONIALES

Lichenophoma Keissl. Vouaux in 71 (1914) considered that a lichen parasite on *Biatorina* (*Lecidea*) *griffithii* described by Lindsay in 68 (1872), 263, belonged to this genus, but Keissler is doubtful, 23, 589.

HYPHOMYCETES

Aegerita physciae Vouaux, 71 (1914), 313. Mycelium web-like, effuse, whitish in colour, but becoming darker and finally destroying the tissue of the *Physcia*. Hyphae hyaline, 3-7 μ thick, in some places forming a rose-tinted cushion (sporodochium). Conidiophores simple, long, 25-35 \times 4-7 μ . Conidia terminal, 10-15 μ diam. Keissler (23, 628) suggests that it may be a state of *Corticium centrifugum*. No definite British records, but owing to its external resemblance to *Illosporium roseum* may have been included in the records of that species.

Atractium flammeum Berk. & Rav. 3, 461; 41, III, 452. Keissler states that it breaks through the underside of *Parmelia subaurifera*, *Physcia stellaris* and *Xanthoria* and is considered to be the conidial stage of *Sphaerostilbe flammea* Tul. 46, 262. It is given as *Microcera coccophila* Desm. in 72, 67. Described in 41.

Coniosporium physciae (Kalchb.) Sacc., *Gymnosporium* Kalchb. in 23, 604; 41, III, 357; 72, 71. Given by Phil. & Plow. in 14, IV (1876), 119, as found on *Physcia* at King's Lynn, Norfolk. Its common host is *Xanthoria parietina*, but it also occurs on *Squamaria*, *Physcia* and *Ramalina*. When on the last-named host it is given as *Spilomium ramalinae* Oliv. in 71 (1914).

Coniothecium graphideorum (Nyl.) Keissl. 23, 618; *Spilomium* Nyl. in 57, 267; 77, 93 (*Spiloma melaleucum* Ach., *S. versicolor* Smith., *S. vario-losum* Turn. & Borr., *S. fuliginosa* Turn., *Coniothecium nigrum* Lam., *C. olivaceum* DC. are prior names before the starting-point of fungal nomenclature). It forms somewhat longish and irregular groups on

the host which it decomposes and blackens. The conidia are \pm muriform, irregularly globose, $6-8\mu$ diam. On *Opegrapha atra* and *O. lyncea* and noted from v.c. 5, 6, 17, 56.

C. lichenicolum Linds. 39 (1869), 518 and 534; *Spilomium* Vouaux, 71 (1914), 321. On thallus of *Buellia*, *Lecanora* and *Pertusaria*, and recorded from various localities in v.c. 38, 40, 48, 64, 78, 83, 85, 88, 89, 92, 104, 107; Ireland, 1, 2, 38. Forms wart-like bodies, punctiform and black. The conidia are $6-12 \times 6\mu$, dark brown, at first \pm globose and later \pm conical.

C. silaceum (Linds.) Keissl. 23, 619; *Gassicurtia* Fée in Linds. 39 (1869), 542; *Spilomium* Nyl. in Vouaux, 71 (1914), 322. Similar to *Coniothecium graphideorum* but not on *Opegrapha*, and the conidia contain oil-drops.

C. sphaerale (Fr.) Keissl. 23, 616; 75, IV, 242; 78, 62; *Sclerococcum* Fr. in 67 (1917), 433; *Acolium corallinum* Krb. in 38 (1869), 342. On the thallus of various lichens, especially species of *Pertusaria*. Some specimens attributed to *Cyphelium stigonellum* A. Zahl. and *C. notarsii* A. Zahl. in 55, 22, and in other British lichenological works, belong here. *Pertusaria corallina*, when attacked by this parasite is 'sometimes referred to a distinct form, f. *papillosa* (Ach.) Zahlbr.', 27, 318. The type is probably common in the British Isles and has been recorded from many botanical vice-counties.

Dactylium lichenicolum Vouaux, 71 (1914), 307, is probably a saprophyte as it occurred on the decayed thallus of a *Parmelia*. It is placed by Karst. as a subspecies of *Dactylium dendroides* Fr. which is given in 41, III, 341, without any definite reference to its occurrence on lichens.

[**Epicoccum neglectum** Desm. in 41, III, 488; 72, 99; occasionally occurs as a saprophyte on *Peltigera* and other lichens.]

Fusarium kuhni (Fkl.) Sacc. in 41, III, 484; 72, 65; *Fusisporium* Fkl. in 14 (1876), 120, where it is given as occurring on mosses and lichens, Norfolk. Keissler's only reference to this species is as a state of *Corticium centrifugum*.

Hyphoderma roseum Fr. 72, 74 with other references; *Hyphelia* Fr. It is considered by Keissler to belong to *Corticium centrifugum*.

Illosporium carneum Fr. 41, III, 468; 72, 57. On species of *Peltigera*.

I. coccineum Fr. in 41, III, 468; 72, 57. On *Endocarpon*, *Pertusaria*, *Lecanora*, etc.

I. roseum Mart. in 41, III, 468; 72, 57; 77, 93. On *Physcia*, *Anaptychia*, *Parmelia*, *Xanthoria* and *Solorina*.

Var. **corallinum** (Rob.) Ferr. 23, 632; 72, 57. On similar lichens as the type.

[**Macrosporium commune** Rabh. in 41, III, 431; *Alternaria tenuis* Nees ex Wallr. in 72, 98 with other references. This sometimes occurs as a saprophyte on *Ocholechia parella*.]

Spegazzinia Sacc. in Michelia, II (1880), 37. A species of this genus was reported as parasitic on *Pertusaria* at Minehead, v.c. 5. Report of the Brit. Myc. Soc. meeting at Minehead, 1920. This probably was *Coniothecium sphaerale* which is found on *Pertusaria* in the Minehead district.

- Sporotrichum lichenicolum** Berk. & Br. in 21 (1872), 102, is given by Keissler as a state of *Corticium centrifugum*. No British locality given.
- [**Trichothecium roseum** Link. in 23, 596; *Dactylium* Berk.; 41, III, 337; 72, 87, with other references. Sometimes occurs on *Stereocaulon* and other lichens, but is a common mould and not a lichen parasite.]

ADDENDUM

The following names are difficult or impossible to arrange in a systematic position.

- Calicium arenarium** Nyl. in 55, 12; *C. citrinum* Leight. in 31, 44, is parasitic on the thallus of *Biatora lucida* (Ach.) Fr., but is included by most authors amongst the lichens.
- Cliostomum corrugatum** Fr. in 28, 69 is given as a parasite on the crust of *Lecidea ehrhartiana* Ach. (= *Biatorina graniformis* A. L. Sm.). According to A. L. Smith (57, 129) the apparent fructifications are the spermatogones of the host.
- Lecidea imponens** Leight. in 68 (1876), 238; 31, 385; 56, 104, which is parasitic on the thallus of *Lecanora polytropha* at Fort Hill, Fishguard, is possibly *Nesolechia vitellinaria* Rehm, but is given as a lichen in 57, 111 and other places cited above.
- '**Opegrapha epiphega**', *Lichen vugasus*, Eng. Bot. On trees near the River Noran, v.c. 90 leg. Don and given on Turner's authority. The specimen in the herb. Edinburgh so labelled is the fungus, *Dichaena faginea* Fr., for which the above are old names, as it was confused with lichens, 75, I, 519. Other Hysteriales, especially *Hysterium angustatum* A. & S. and *H. pulicare* Pers., are often mistaken for species of *Opegrapha* or other Graphidiales. *Gloniopsis levantica* Rehm, when associated with a lichen thallus, is liable to be mistaken for a *Dictyographa*. On the other hand, mistakes may be made in an inverse direction. For example, *Gloniopsis watsoni* Rilstone, which was described in the *J. of Botany* (1940), 192 as occurring on an indeterminate lichen thallus is a form of the lichen *Graphina ruiziana* Müll-Arg., with most apothecia longer than usual and with the algal cells of the thallus more obscurely trentepohlioid.
- Pyrenotheca aphanes** Leight.; *Verrucaria* Borr. in 28, 67; 56, 202; 57, 223-4.
- P. leucocephala** Fr. in 28, 65; *Sphaeria* Pers. in 56, 202; 57, 223.
- P. lithina** Leight., *Verrucaria* Tayl. in 28, 68; 56, 296.
- P. lutea** Leight. in 28, 68; 56, 296.
- P. mollis** Leight., *Verrucaria* Tayl. in 28, 67; 56, 296.
- P. niveoatra** Leight., *Verrucaria* Borr. in 28, 67; 56, 296.
- P. rudis** Leight., *Verrucaria* Borr. in 28, 66; 56, 202; 57, 223.
- P. stictica** Fr. in 56, 205; 57, 226.
- P. sulphurea** Leight. in 28, 69; 56, 296.
- P. vermicellifera** Leight. in 29, no. 292; 56, 202; 57, 223.

All the above-mentioned *Pyrenotheca* (*Sphaeria* and *Verrucaria*) species are considered to be spermogonia of *Lecanactis abietina*, *Platygrapha periclea*, *Opegrapha* species and other lichens.

Thrombium epigaeum Wallr., *Sphaeria* Pers. and other synonymy in 57, 336, is considered as a true lichen. Acharius's subgenus *Inoderma* was raised to generic rank by S. F. Gray, who included in it two British species, *I. epigaea* and *I. byssacea*, the latter of doubtful position based on *Sphaeria byssacea* Weig. and considered by some authors as a spermogonial form, 57, 335.

Verrucaria conturmatula Nyl. in 14, VIII, 29; *V. elachistophora* Nyl. in 31, 454; **V. harrimanni** Ach. in 28, 63; **V. pulposa** Leight. in 30, 427; 31, 457, are given by A. L. Smith as parasitic or doubtful species, 56, 295-6; 57, 321-2.

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* Some mistakes may occur in the references No. 68 and 69. Some of the copies were imperfectly "spined" so that mistakes in number of volume or year of issue were easily made.

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(Accepted for publication 17 March 1947)

EMENDATIONS TO THE THIRD EDITION OF THE LIST OF COMMON BRITISH PLANT DISEASES

BY A SUB-COMMITTEE* OF THE PLANT PATHOLOGY COMMITTEE
OF THE BRITISH MYCOLOGICAL SOCIETY

The third edition of the *List of Common British Plant Diseases*, compiled by the Plant Pathology Committee of the British Mycological Society, was published in 1944. Since then a number of emendations and additions have become necessary, and these are given below, together with the number of the page in the third edition where the change or addition should be made. Following the practice now general among botanists, specific epithets have been decapitalized. Until there is a generally accepted set of international names for viruses, the common names used for virus nomenclature in the *Review of Applied Mycology* (Special Part, vol. xxiv, part 13, 1946) are accepted.

APPLE, p. 9. To Bitter Rot add 'and *Gloeosporium perennans* Zeller & Childs'.
APPLE, pp. 9-11. Add the four entries:

- 'Dry Eye Rot and Soft Rot... *Botrytis cinerea* Fr.
- 'Perennial Canker... *Gloeosporium perennans* Zeller & Childs.
- 'Chlorosis (lime-induced)... Iron deficiency.
- 'Magnesium Deficiency... Non-parasitic.'

BARLEY, p. 12. Brown Rust. The name *Puccinia hordei* Otth (1871) was considered in 1939 (these *Transactions*, xxiii, 279) and, though it was recognized to be the earliest name, it was at that time thought best to regard it as a *nomen ambiguum*. However, Buchwald (1943) has restated his case, and has now provided a valid name for the homonym *P. hordei* Fuckel (1873). *P. hordei* Otth, which is the valid name under the Rules for this Brown Rust fungus, has recently been accepted by the U.S. Department of Agriculture (Stevenson & Johnson, 1946) and we recommend that it be accepted here also. In view of the confusion in the literature over the names *P. anomala* and *P. simplex*, it is hoped that *P. hordei* Otth may provide a name to be used everywhere.

BEAN, BROAD and FIELD, p. 13. Chocolate Spot. To *Botrytis cinerea* Fr. add 'and *B. fabae* Sardiña'.

CHERRY, p. 17. To Bacterial Canker add 'and Leaf Spot'. The same addition under PLUM, p. 32.

CUCUMBER, p. 19. Add the entry 'Stem and Fruit Rot... *Pythium ultimum* Trow and *P. aphanidermatum* (Edson) Fitzpatrick'.

* The sub-committee is G. R. Bisby (convenor), K. St G. Cartwright, H. E. Croxall, E. W. Mason, W. C. Moore and Miss E. M. Wakefield. These emendations have been approved by the Plant Pathology Committee.

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- FLAX, p. 21. To *Fusarium lini* should be added the synonym *F. oxysporum* Fr. f. *lini* (Bolley) Snyder & Hansen. Although the proposals of Snyder and Hansen regarding formae of *F. oxysporum* have been commonly accepted in North America, it seems best to follow Wollenweber and Reinking until there is more general agreement as to the taxonomy and nomenclature of *Fusarium*. After Rust add the entry 'Mildew... *Oidium lini* Škorić'.
- GLADIOLUS, p. 22. Botrytis Rot and Core Rot. Change '*Botrytis* sp.' to '*Botrytis cinerea* Fr.'
- GRASSES, p. 23. The entry 'Stripe Smut... *Ustilago striiformis* (Westend.) Niessl' requires no change; but, to lessen the danger that someone might propose an undesirable change, we endorse the view presented by Stevenson (1946) that the earlier name *U. salvei* B. & Br. should be considered a *nomen ambiguum*.
- MUSHROOM, p. 27. Add the entry 'Verticillium Disease... *Verticillium malthousei* Ware'.
- OAK, p. 27. Mildew. Robertson and Macfarlane (1947) report a few perithecia, which they identified as *Microsphaera alphitoides* Griff. & Maubl., on *Quercus robur* in Herts.
- OATS, p. 28. Loose Smut. Stevenson & Johnson (1944) find that the fungus should be cited as *Ustilago avenae* (Pers.) Rostr. (1890). Jensen in 1889 used the binomial *U. avenae* as a *nomen nudum*.
- ONION, p. 28. Add the entry 'Leaf Blotch... *Heterosporium allii* Ell. & Martin var. *cepivorum* Nicolas & Aggéry'.
- PLUM, p. 32. Add the entry 'Chlorosis (lime-induced)... Iron deficiency'.
- POTATO, p. 34. Add the three entries:
 'Leaf Scorch... Potassium deficiency and other causes.'
 'Premature Tuber Formation (Little Potato)... Non-parasitic.'
 'Glassiness... Non-parasitic.'
- RHODODENDRON, p. 35. To Leaf Scorch add 'and Bud Blight'.
- SPINACH, p. 37. Add the entry 'Leaf Spot... *Heterosporium variabile* Cooke'.
- STRAWBERRY, p. 37. Add the entry 'Leaf Blotch... *Zythia fragariae* Laibach. The perfect state is an undetermined species of *Gnomonia*'.
- TOMATO, p. 39. To Grey Mould and *Botrytis* Fruit Spot add 'and Soft Rot'.
- TOMATO, pp. 39-40. Add the three entries:
 'Alternaria Blight... *Alternaria solani* (Ell. & Martin) Sor.'
 'Bacterial Canker... *Corynebacterium michiganense* (E. F. Sm.) H. L. Jens.'
 'Magnesium Deficiency... Non-parasitic.'
- TURF, p. 40. Petch (1945) has strongly reinforced the view expressed on p. 7 of the List that 'It might have been even better to accept *Calonectria nivalis* Schaffnit' instead of *C. graminicola* Wollenw., and it is therefore proposed that *C. nivalis* be accepted.
- VIOLA, p. 41. Change the first entry to read: 'Root and Stem Rot... *Pythium violae* Chesters & Hickman, *Myrothecium roridum* Fr., and sometimes other fungi.'
- WALNUT, p. 42. Graft Disease. Delete the entry regarding the perfect state. Baker and Thomas (1946) did not obtain any evidence that *Chalaropsis thielavioides* has a perfect state.

WHEAT, p. 42. Add the entry 'Sharp Eyespot... *Corticium solani* (Prill. & Delacr.) Bourd. & Galz., stat. mycel. *Rhizoctonia solani* Kühn'.

The following names are now to be added to the list of author's names:

Aggéry [Berthe]	Nicolas [G.]
Chesters [C. G. C.]	Sardiña [J. R.]
Childs [L.]	Škorić [V.]
Jens[en] H. L.	Ware [W. M.]
Laibach [F.]	Zeller [S. M.]
Martin [G., 1827-86]	

The following dates can be added to the printed list:

Henn[ing, E., 1857-1929]	Lind [J., 1874-1939]
Jones, L. R. [1864-1945]	Schilb[ersky, K., 1863-1935]
Kabát [J. E., 1849-1925]	Syd[ow, H., 1879-1946]
King [Charlotte M., 1864-1937]	Tak[ahashi, Y., ?-1914]
Kleb[ahn, H., 1859-1942]	Towns[end, C. O., 1863-1937]
Lambert, F. [1859-1940]	

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(Accepted for publication 18 August 1947)

DISEASE MEASUREMENT IN PLANT PATHOLOGY

In 1941 the Society's Plant Pathology Committee formed a Sub-Committee to study methods of disease measurement in the field. A preliminary report was published (Moore, 1943) and this was followed by short progress reports (*Trans.* 1943-7). Altogether, methods of measuring disease intensity have been laid down for the following diseases:

CEREALS	Smuts; Take-all; Eyespot; Brown Foot Rot.
POTATO	Blight; Leaf Roll; Leaf Drop Streak; Rugose Mosaic (= Severe Mosaic).
SUGAR BEET	Yellows.
APPLE	Scab.

The methods recommended for all these diseases, except Apple Scab, have been given in the progress reports.

Percentage infection method

The simplest method of disease measurement is to estimate the percentage infection. For wide surveys the records may take the form of the percentage of crops in a district in which a disease occurs, and may be designated as *P* (disease prevalence).

Usually the figure obtained for the amount of disease is the percentage of plants infected in a whole plot, or in samples taken from the crop at random, and is obtained simply by counting and averaging the samples. This method is applicable to all the diseases in the above list, except Potato Blight and Apple Scab, which normally develop on every plant in the crop. Figures obtained in this way may be designated by the letter *I* (percentage of infection).

The method of taking the samples will vary with the crop and the disease. To save time and labour it is desirable to take no more than the minimum required to give accurate results. Generally speaking ten samples are adequate within one plot or crop, provided they are satisfactorily randomized. If, however, there is considerable variation in the results from the ten samples, another ten samples should be taken. With plots in which varieties are replicated several times, the random sampling should be made over the whole of the replicates, and not concentrated on a few plots with only a proportion of the replicates sampled.

Disease index method

For diseases in which the amount of disease is variable on different plants within the crop the figure for *I* may give an inadequate measure of the disease intensity, and it becomes desirable to assess the amount of disease on each plant. This has been done by reference to an arbitrary scale.

The simplest type of scale is of the qualitative type, e.g. healthy, slight, severe. But even this scale has drawbacks: (1) different observers, or the

same observer in different seasons, may show disagreement over borderline cases, and (2) comparison of disease severity may be ambiguous, e.g. it is not certain whether 50 % slight and 10 % severe is more or less severe than 30 % slight and 15 % severe. The first difficulty, or the personal equation, may be largely surmounted where groups of observers work together to check each other's assessments periodically, but the second becomes important as more elaborate scales are adopted.

Americans have widely used the 'Disease Index' method by which the observations of disease intensity are averaged out to a single figure (Walker, Larson & Albert, 1938). Suppose there are five grades 1, 2, 3, 4, 5 measuring the amount of disease: if N is the total number of plants, and N_1, N_2, N_3, N_4, N_5 are the numbers of plants in each grade, then the Disease Index figure, which may be designated DI , is

$$\frac{N_1 + 2N_2 + 3N_3 + 4N_4 + 5N_5}{5N} \times 100.$$

Any inaccuracies in placing the observations in the right categories will increase the error of the final figure, and another error will be introduced if the amounts of disease in the different categories are not proportional to the numbers of the categories. A few observers have surmounted the second difficulty by giving numbers to the categories equal or proportional to the percentage of leaf area destroyed. This modification leads on to a third method of disease measurement.

Percentage affected leaf-area method

Direct estimation of the percentage leaf area affected gives figures which may be designated DM .

The method is particularly appropriate for diseases such as Potato Blight in which normally every plant is affected. Some sort of 'standard' is essential, although the amount of use of, or frequency of reference to, the standard will vary with individual skill and temperament. For field survey it is usually sufficient to classify into 'group percentages' with a range of 5 to 10, or even up to 25 at the less important parts of the scale. Some prefer to use 'standard area diagrams' or 'standard photographs', but the method which is gaining most support in this country at present is the use of the 'standard (descriptive) key', carefully prepared after preliminary investigations of the disease, and modified during the first few years of its use in the light of field experience.

With the aid of such standard keys the percentage leaf area affected by the disease can be estimated fairly accurately. The assessments can be made on single plants, but are just as easily carried out on small handfuls selected at random, or even on whole plots, for which the method is primarily designed. With certain crops it may be desirable to record the observations for two or three different height levels (b , m and t = bottom, middle and top).

Experience has shown that the personal equation is less serious with this than with other methods, because the measurements have reference to

a standard key. Also the values for *DM* have a direct biological meaning, and observations on different dates on the same plots or fields in any season can be plotted in a curve, which is normally sigmoid in character. Furthermore, it is an advantage to have one simple uniform method for different diseases. It is, of course, necessary to construct a separate key for each disease, and this is a matter for specific investigation. It is a further advantage that, as the crop yield depends on the amount of leaf functioning during the season, it should be possible to correlate disease measurement with crop yield. Estimates of losses of crops, and decreases in financial returns, with resulting wise direction of national research into control methods for the diseases placed in order of priority, should be the ultimate objective of all disease measurement work.

A good example of the value of these methods is given by the observations (Large, 1945) on potato blight spraying trials.

Enough of the preliminary work has been done to enable rapid progress to be made, even if that progress is along a rather irregular front. A lead has been given and interest in the subject has been created in this country. The Society's Sub-Committee is therefore confidently content to leave the future organization of disease measurement work in the hands of the Disease Assessment Sub-Committee recently appointed by the Conference of Plant Pathologists of the National Agricultural Advisory Service. It is intended that this new Sub-Committee shall be broadened to include workers interested primarily in the research side as well as the specialist advisers.

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(Accepted for publication 30 June 1947)

SUGGESTIONS FOR AN INTERNATIONAL HERBARIUM OF PLANT PATHOGENIC FUNGI*

By PAUL NEERGAARD

The publication of mycological exsiccatae in the past has been almost exclusively a matter of private initiative. The great value of this tremendous collecting work performed during the past century should not be underrated, but it must be admitted that in most cases the material has been collected by chance and determined by mycologists who could not possibly be specialists in the numerous fungous groups with which they dealt. The many misidentified specimens do more to complicate than to simplify identification of new material, and a short cut to sure determination is badly needed, especially for plant pathologists.

The publishing of an International Herbarium, based on contributions from selected specialists, with the nomenclature steadily kept up to date, would make it possible to establish a much needed co-operation between the mycological taxonomists and the plant pathologists, who often cannot spend much time on taxonomic studies. I propose the following principles to be taken into consideration for the realization of the suggested Herbarium.

1. COLLECTING

The purpose of the herbarium is to facilitate identification of plant pathogenic fungi: hence, saprophytic forms belonging to genera containing parasitic forms must be included. Examples of groups entitled to be included are: *Alternaria*, *Ascochyta*, *Botrytis*, *Cercospora*, *Ciboria*, *Cladosporium*, *Colletotrichum*, *Coniothyrium*, *Cylindrocarpon*, *Cystopus*, *Cucurbitaria*, *Didymella*, *Diplocarpon*, *Entyloma*, *Erysiphaceae*, *Fusarium*, *Gloeosporium*, *Helminthosporium*, *Heterosporium*, *Marssonina*, *Mycogone*, *Mycosphaerella*, *Nectria*, *Ovularia*, *Peronospora*, *Pestalozzia*, *Phoma*, *Phyllosticta*, *Phytophthora*, *Plasmodiophora*, *Polyporus*, *Pythium*, *Ramularia*, *Rhizoctonia*, *Rhynisma*, *Sclerotinia*, *Septoria*, *Sphaceloma*, *Stagonospora*, *Stemphylium*, *Taphrinaeae*, *Uredinales*, *Ustilaginales*, *Venturia*, *Vermicularia*, *Verticillium*.

Whenever possible material of the same fungus (same collection) should be issued from (1) a natural substratum, (2) an artificial medium, as an isolate.

All the material for a given specimen should be taken from one locality and one crop or substratum. Enough material should be collected to satisfy any request to be expected for a long period of time. If, for example, 500 labelled packets should be made to cover the demand for some years, an ample supply of reserve material should be kept for dividing and packeting later, if that should prove necessary.

2. DETERMINATION

The determination should be based on the co-operation of specialists, invited to take care of the groups in which they have specialized. More than one specialist in a group can be invited, and it is even preferable that the material be determined by two specialists, who should be cited as determiners on the label. For a long time it would probably be impossible to find specialists for all the fungus groups that should be represented. But in any case it would be preferable to limit the issuance of items to the forms for which a well-documented determination could be given. Specialists of single species could be invited to contribute material of the species in question.

In brief, the old herbaria rendered material incidentally found and more or less tentatively determined. For the suggested herbarium, the collecting work should follow a pre-arranged plan: the forms to be included should be well known to specialists and should—as far as possible—be chosen in advance and, at the beginning, be selected preferably from the economically or taxonomically more important forms.

* Though pleased to publish this contribution from an eminent Danish colleague, the Council of the Society wish to point out that they do not necessarily share his views.

3. LABELLING

The following data are proposed to be given on the label (see sample label below):

- (a) Name of the exsiccata
- (b) Issue number of the specimen
- (c) Name of the fungus, including author(s) and date of publication
- (d) Synonyms, including author's name(s) followed by date of publication
- (e) Substratum (host, artificial medium)
- (f) Date and locality of collection. For material obtained by culture:
 - (aa) Date of isolation
 - (bb) Substratum from which the fungus is isolated and the date and locality of the collection of that material
 - (cc) Date of transferring the fungus to the medium used for the issue
 - (dd) Date of drying the culture
- (g) Bibliography:
 - (aa) Reference to original diagnosis
 - (bb) Reference to the first use of accepted name
 - (cc) Reference to diagnosis in Saccardo *Sylloge Fungorum*
 - (dd) Monograph(s)
 - (ee) Most important literature. If data on the specimen are published, this should be specially indicated
- (h) Name of determiner(s)
- (i) Remarks on possible deviations of the specimen from the normal form (the type)
- (j) In case of dispute on the nomenclature, references to be made to papers containing the determiner's arguments. Where there is complete disagreement between two selected authorities (as to type of the species, etc.) duplicate labels should be attached
- (k) Date of issuance of the label, and number of the edition, e.g. *March 1952, 2nd edition*

HERBARIUM PHYTOPATHOLOGICUM NOMEN NESICIO

No. 123 1st edition of label, issued Aug. 1952

Heterosporium iridis (Faut. & Roum.) Jacques 1941

Syn.: *Scolecotrichum iridis* Faut. & Roum. 1891.

Heterosporium montenegrinum Bub. 1903.

Scolecotrichum cladosporioideum Maire 1906.

On malt extract agar, isolated 19 Feb. 1950 from *Iris germanica* (coll. 2 September, 1949 in Branchport, New York, U.S.A.—material issued as Herb. Phytopath. N. N. No. 122), transferred last time 22 March, 1950, the culture dried 3 April, 1950.

References:

Original diagnosis: Roumeguère: Fung. Sel. Gal. Exs. No. 5689. 1891.

New combination: Jacques, J. Émile: Studies in the genus *Heterosporium*.—*Contr. de l'Inst. Bot. de l'Univ. Montréal*, No. 39: 1-59. 1941.

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New labels should be issued to provide for corrections of possible errors in identifications, to take care of new combinations, new synonyms, or to cite new important literature—in brief, to keep the herbarium up-to-date.

4. PUBLICATION OF NEW SYSTEMATIC ITEMS (NEW SPECIES ETC.)

New species etc. can be accepted for publication in the herbarium when a sufficient amount of type material (on host or on artificial medium) is rendered and recognized by the appointed specialists taking care of the fungus group in question.

Obviously the realization of a herbarium as outlined above would be a very large undertaking which undoubtedly would have to be built up gradually. The co-operation of mycological taxonomists must be based primarily on voluntary effort. The result might be, therefore, that some groups would be predominantly represented because of more diligent co-operation of some of the appointed specialists than of others. But with time that can be regulated. It would be the object of the enterprise to make the exsiccatae so valuable and well documented that all the main institutions of the world performing mycological and plant pathological investigations would be willing to subscribe for a complete set, thus facilitating identical determination of at least the most common and the most important plant pathogens.

(Accepted for publication 30 June 1947)

AUTUMN FORAYS, 1946

THE SANDSEND FORAY

14-20 September 1946

It was most fitting that the first post-war Annual Autumn Foray, the first since 1938, should be held in the Jubilee year of the Society; appropriate too that the Yorkshire Naturalists' Union should join forces for the occasion with its younger sister society. Headquarters were at the Bungalow Hotel, Sandsend, near Whitby, and, although accommodation was a little cramped, everything possible was done for the convenience of the party, including the turning of one of the two lounges into a workroom. Some eighty members belonging to one or both of the two societies were present, a gratifying feature being the number of young enthusiasts who were evidently enjoying their first experience of a full-scale foray.

Conditions were somewhat unusual owing to the abnormal amount of rain which had fallen during the summer. Much of the ground was almost or quite waterlogged, so that the larger fungi were scarce in most of the areas visited; the fact that these organisms require air as well as moisture was only too well demonstrated. Those who arrived late on Saturday were soon informed, by members who had reached Sandsend earlier in the day and had already carried out a preliminary survey, that Mulgrave Woods were likely to be disappointing. The Woods, which lie close to the Hotel, were visited in force on Sunday morning, and it was soon evident that the ground, even in the higher portions of the area, were almost completely sodden. There was a fine patch of *Psathyrella disseminata* at the entrance to the Woods, and a crop of unusually large specimens of *Auricularia auricula-judae* was found on a fallen branch of *Sambucus*, but although the total number of agarics collected, in this and subsequent searches, was not inconsiderable, most species were found as isolated specimens and many were somewhat atypical.

On Sunday afternoon a large party went to Skelder Plantation, which lies on higher ground. In general, fungi were more abundant here than in Mulgrave Woods, but there was little variety and nothing of special importance. In the evening Dr Grainger gave a paper, illustrated by lantern slides, entitled 'From Foray to Farm Practice', giving the results of an ecological study of *Erysiphe graminis*, and showing how observations made at forays may be used to help the agriculturalist to combat disease.

Forge Valley was visited by motor-coach on Monday. A few well-drained areas on the steep slopes of the enclosing hills yielded many specimens of *Lactarius deliciosus* and *Hygrophorus virgineus*, but otherwise finds were few and far between. A high spot of the outing was undoubtedly to drive back over the moors in the late afternoon. In the evening Mr A. A. Pearson gave a public lecture on 'Mushrooms and Toadstools', with coloured lantern slides, in the schoolroom at the neighbouring village of Lythe, and a goodly contingent from the Hotel climbed the mile-long hill to help swell the audience.

On Tuesday there was another coach trip to Egton, Arncliffe Woods, and Guisborough Moor—at least that was the route as planned. The first part of the day's outing went according to schedule and, in spite of some rain, collecting was fairly successful. However, when starting on the last stage of the journey, the driver of one of the two coaches, in attempting a delayed gear-change, broke a shaft. Fortunately habitation was not far away and the stranded half of the party, including the President, whiled away a pleasant hour over tea, until a relief coach could be sent from Whitby. The following day there was no organized excursion. Many members took the opportunity to see something of the ancient port of Whitby, whilst others continued collecting in the Mulgrave area. After dinner, the workroom in the hotel was crowded for an informal discussion, organized by Dr Grainger, on the ecology of fungi, the general conclusion reached being that much more work on the subject is required before we can even begin to generalize.

Thursday brought showery weather and only two members set off for Grinkle Park, one of the areas originally planned for a foray. They returned triumphant with representatives of close on 100 species, including a fine selection of brilliantly coloured species

of *Hygrophorus*, good specimens—the only ones collected during the Foray—of *Polyporus picipes*, and the somewhat uncommon *Clavaria luteo-alba*.

On the whole the most successful hunting was done by the micro-fungi contingent, as there was no lack of interesting material. There were few times in the day, except meal-times, without the sound of choppers and saws, and the devotion of certain members to their microscopes during all the hours when out-door foraging could not be indulged in was exemplary. In all seventy Pyrenomycetes and fifty-one Hyphomycetes were collected and identified, including three new records for Yorkshire. *Chaetosphaeria cupulifera* (B. & Br.) Sacc., was found in association with *Catenularia cuneiformis* (Richon) Mason on wood of *Quercus*; *Rhamphoria tympanidispora* Rehm, especially interesting because the ascospores bud inside the ascus, was collected on rotten wood of *Quercus*; and *Gonatobotryum fuscum* Sacc. was found growing on the end of an oak log intended for the fire. The latter fungus has been found only three times in this country, the first British record being from an oak log in a hotel wood-pile at Haslemere in 1945 (*Trans. Brit. myc. Soc.* 1946, xxix, 97).

A full list of the fungi collected during the Foray has been published by Dr Grainger, Miss Grainger and Mr W. G. Bramley in the *Naturalist* (1947, April-June, pp. 83-90). The list includes many species which are not to be found in Mason and Grainger's *Catalogue of Yorkshire Fungi*.

LONDON FORAY

1946

Four one-day forays were held in the London area. At the first of these, on 28 September, Mad Bess Wood, Ruislip was visited, and the impression on entering the wood, noted particularly by those who had experienced the scarcity of agarics at the Sandsend Foray, was of a welcome abundance of fungi. However, it was soon evident that it was a case of quantity rather than variety. Species of *Russula*, and the small brown species of *Lactarius*, particularly *L. quietus* and *L. subdulcis*, were everywhere. It is noteworthy that not a single specimen of the usually common *Paxillus involutus* was found, and only a few undersized specimens of *Boletus* were collected. Species of *Clavaria* were unusually plentiful, including *C. fusiformis*, *C. cinerea*, *C. cristata*, *C. inequalis*, *C. kunzei*, *C. rugosa*, and *C. umbrinella*.

A joint foray with the London Natural History Society, Ecological Section, was held at Bookham Common on 29 September. South-east and Central Woods were worked in the morning and afternoon respectively and a fairly large number of specimens were collected, although nowhere was there abundance. Again *Paxillus involutus* was missing and of *Boletus* only a few specimens of *B. scaber* were found. The most interesting discovery was on an old and decrepit *Pyrus malus*. One of the two main stems bore hundreds of caps of *Marasmius ramealis*, although the tree, in spite of its poor condition, was still bearing a fair crop of fruit. One patch of abnormally large specimens of *Entoloma lividum* was found under an oak, and several dense clusters of *Leotia lubrica* were seen.

On 5 October, Harrow Weald Common and Grim's Dyke were visited in conjunction with the Herts Natural History Society. Amongst the more interesting finds were *Geaster fornicatus*, *Amanita porphyria*, *Boletus custaneus* and *Peziza aurantia*. The Society is much indebted to Mr Swallow, of Harrow Weald Grammar School, who assisted in making the arrangements, entertained the party to tea in the school, and threw open the biological laboratory for identification and display of specimens.

The season ended with a foray at Oxshott on 12 October. A fairly large number of fungi were collected but nothing of outstanding interest was recorded.

G. SMITH
Sec. Foray Committee

THE TWENTY-FIRST ANNUAL PLANT PATHOLOGY FIELD DAY

27 June 1947

The Twenty-first Annual Field Day was held at the School of Agriculture, University College, Nottingham, Sutton Bonington, by permission of Prof. H. G. Robinson. Nearly fifty members and friends attended.

The programme began at 11.30 a.m. with a demonstration of the soft-fruit plots used in training Inspectors for the Ministry of Agriculture's Certification Schemes. Mr Martyr then conducted the party on an interesting tour of the Horticultural Department during which there was a lively discussion on some of the diseases present.

The members were the guests of the School of Agriculture at lunch. After lunch the President of the Society, Prof. C. G. C. Chesters, thanked Prof. Robinson and his staff for their hospitality and for arranging a most interesting programme. In replying, Prof. Robinson outlined the developments which were taking place at the School of Agriculture. In the afternoon Dr A. R. Wilson gave an account, illustrated by exhibits, of methods for storing potatoes which he had seen in the United States. He also discussed the problems of potato storage under English conditions and the work that was being done on them.

Under the expert guidance of Mrs N. McDermott a tour was also made of the potato plots. This proved of great interest, although it was somewhat curtailed by a thunderstorm. After tea in the Canteen most members returned to the potato plots where Dr Gregory demonstrated the results so far obtained on the spread of potato virus diseases. Members also took the opportunity of seeing other potato plots in which they were particularly interested. The party dispersed at about 5.30 p.m.

H. E. CROXALL
Sec. Plant Pathology Committee

REVIEW

North American Species of Mycena. By ALEXANDER H. SMITH. University of Michigan Studies, Scientific Series, vol. xvii. (Ann Arbor, Michigan: University of Michigan Press; London: Oxford University Press, 1947.) xviii + 521 pp., 56 text-figures, 99 uncoloured plates. \$6.00.

With the increased use of the microscope in the study of the higher fungi ideas as to their classification have in recent years undergone a revolution, but are still in a state of flux. Many new genera have been established, while, on the other hand, some old genera have been united on the basis of microscopic characters, as, for instance, the genus *Rhodophyllus*, which includes all the pink-spored Agarics with angular or nodulose spores. One of the earliest genera of Agarics to be studied microscopically was *Mycena*, for many species of which Schroeter in 1889 described cystidia and spores. Since that time *Mycena* has been the subject of several revisions. Von Höhnelt, in 1913, proposed a classification of the European species based on the characters of the cystidia, and Lange (1914 and 1936) divided the section *Eumycena* into two groups, *Ciliatae* and *Granulatae*, according as the cystidia were smooth and more or less pointed or rounded, with spines or finger-like

appendages. Oort, in 1928, published a revision of the *Mycenas* of the Netherlands, and Kühner in 1938 produced an elaborate monograph of the European species of *Mycena*, in which he emphasized the importance of not only cystidia and spores but also the structure of flesh and gills, the covering of the pileus and stem, and the iodine reactions of both spores and hyphae. In America Kauffman, in 1918, described cystidia and spores for the species of *Mycena* found in Michigan, and Beardslee and Coker, in 1924, gave an account of the *Mycenas* of North Carolina with drawings of microscopic detail. Between 1935 and 1939 A. H. Smith published some preliminary studies of North American *Mycenas*, and this author has now completed a monograph of the North American species of the genus.

As might be expected, the North American flora is much richer in species than is the European; the present work includes descriptions of 218 species, as compared with 143 recognized by Kühner for Europe. Most of the European species are found also in North America, but the student who is using this book, along with say Kühner's monograph, may find differences of interpretation of some of the old species. Unfortunately, the older mycologists seldom thought of preserving specimens of the Agarics which they described, and the descriptions alone are often insufficient to indicate precisely which of two or more outwardly similar species was in question. Thus it comes about that different authors may interpret some of Fries's species in different senses. The species which is known in this country, and to Lange, Oort and Konrad and Maublanc as *Mycena filopes* is described by Kühner under the name of *M. vitilis* Fr., while Kühner's *M. filopes* is what these other authors call *M. vitilis*. Smith, in the present work, distinguishes a species with no particular odour which he calls *M. filopes* from one with a distinct smell of iodoform which is referred to *M. iodiolens* Lundell. Again, a student who is trying to identify the common *Mycena* of pine woods with red-edged gills and a distinct nitrous smell would, if using either Kühner or Smith, come to the name *M. capillaripes* Peck. Yet in this country this species is usually referred to *M. rubromarginata* Fr., a name which is given to a different fungus by the authors mentioned. One of the most urgent needs for mycological nomenclature is some guidance as to the selection of type, or the method of fixing the application of a name, in such cases as these where no authentic or type specimen exists. If no agreement can be reached, it would be better to discard some of these old names, as is suggested by Smith for '*Mycena chlorantha* Fr.' It is a relief to find that Dr Smith is, on the whole, conservative both in his conception of the genus and in his interpretation of old species. For purely American species his task has been easier, since the type specimens of many of these exist and he has been able to examine them.

After an exposition of his broad concept of the genus *Mycena*, which includes certain species formerly described as *Collybia* or *Omphalia*, the author discusses in detail the various diagnostic characters used for species and describes his technique. Then follows an explanation of his grouping of the species into four subgenera, and an attempt is made to place related species together in small groups or stirpes within the adopted subgenera and sections.

The descriptive portion of the work, which occupies pages 43-452, is provided with keys to subgenera, sections and species, and includes full descriptions of all species known to the author. He has also added (pages 453-470) emended descriptions of Murrill's tropical and subtropical species of *Mycena* and *Omphalia*, drawn up from examination of the type specimens.

Details of microscopic structure are shown in line drawings, and at the end of the book are 98 plates depicting in half-tone reproductions from photographs the habit of fresh specimens of those species known to the author at first hand. One would have preferred coloured figures, but in these days the expense of colour printing is a limiting factor. With the help of the photographs and the microscopic characters together it should be possible to determine any given species with some degree of certainty. The book is completed by a list of doubtful or excluded species and a bibliography of 12½ pages. As in other books published by the University of Michigan Press the format is good, the text and drawings clear and easy to consult. The serious student of the genus will find the work valuable and interesting to compare with Lange and Kühner. Especially useful are the critical observations which follow the description of each species.

PROCEEDINGS

GENETICS AND CYTOLOGY OF FUNGI

Joint meeting with the Genetical Society held in the rooms of the Linnean Society of London on Saturday, 8 March 1947.

S. DICKINSON (School of Agriculture, Cambridge). Fungal Genetics.

The study of fungal genetics has hitherto been a study of haploid inheritance. The size of the nuclei has prevented any considerable advance by joint cytological and genetical studies. The association and dissociation of nuclei in multinucleate types has been a fruitful subject for investigation. The linear and naked arrangement of the products of segregation in such fungi as the Smuts may provide a profitable line of research on polarity or biased segregation.

ELIZABETH BLACKWELL (Royal Holloway College). The morphology of the strains of certain heterothallic fungi and the terminology of the organs of fusion.

A review of the many different mechanisms which have been evolved in the fungi for bringing haploid nuclei together, and ultimately forming the zygote, suggests a critical consideration of the terms in use for the organs of syngamy: names of organs found in algae and assuming homology with them. The unit of the fungus is a hypha, not a cell, and hyphae readily fuse with one another.

A few examples taken from the 'higher fungi' will serve. In *Pyronema confluens* and *Ascobolus magnificus* there are specialized hyphae of fusion called, unfortunately, 'antheridium' and 'ascogonium', sometimes even 'oogonium'. In the former (homothallic) species these arise close together: in the latter (heterothallic or better, homothallic and self-sterile) species they develop only on contact of the strains though both strains bear both types of hypha. In the former there is no risk of their not meeting and it is significant that here there are no accessory spores. The strains of the latter species are widely dispersed by papulospores, and so brought together. In *Pleurage* (= *Podospora*) *anserina* there is only one specialized hypha, the so-called 'trichogyne'; and the haploid nucleus of opposite strain comes direct to it in a microconidium, transported by air, or water, or insects, and is absorbed by it. This is a very efficient mechanism. Fusion of conidium with conidium occurs in yeasts and smuts, and this association of strains by two transportable units is even more efficient. In species of *Puccinia* there is ready fusion between unspecialized hyphae, thus bringing haploid nuclei into the same segment; but in heterothallic species, e.g. *P. graminis* and *P. helianthi*, the chances of association of different strains are increased by the production of a transportable unit, viz.: the insect-borne pycnidiospore, which is absorbed by a flexuous hypha growing out from the pycnidium of opposite strain. This is equivalent to 'spermatium' and 'trichogyne' of *Pleurage anserina*, but there is no need to call these 'sex organs'. Indeed the colour, scent and nectar of the pycnidium recall *pollination*, the transport of a spore, rather than *fertilization*, the fusion of ovum and sperm. It is significant that the homothallic *Puccinia malvacearum* does not produce pycnidia. In the heterothallic *Coprinus lagopus* there is ready fusion of hyphae, and again the conidia produced on the haploid mycelia increase the chances of strains meeting. Three phenomena in these 'higher fungi' deserve our attention: (a) the delay of fusion of associated haploid nuclei; (b) the development of a hook hypha: the 'crozier' of ascomycetes, the 'clamp connexion' of basidiomycetes; (c) the fact that, except in the yeasts, immediately after fusion, meiosis follows: there is no resting spore with a diploid nucleus.

It would seem that in this unique group of the fungi, quite original and independent methods of breeding and cross-breeding are found, analogous to, but not homologous

with, the methods of plants in general. In conclusion, (a) the different so-called 'sex organs' may have been derived independently from vegetative hyphae which had already developed a tendency to fuse with one another; (b) the conidium (oidium, papulospore, spermatium, etc.) is efficient in effecting the wide distribution of a haploid strain, *even when it cannot germinate of itself* but must needs be absorbed by a receptive hypha, and that this is of importance not only in the ultimate association of different strains, but in increasing the chances of hybridization; (c) for the mere association of haploid nuclei neither heterothallism nor the production of special organs of fusion is *necessary*.

C. ROBINOW (Strangeways Laboratory, Cambridge). On the staining of nuclei in bacteria and fungi.

In preparations stained by conventional methods the nuclei of bacteria are usually invisible. The reason for this lies in the strong affinity of the cytoplasm for basic stains which is due to its high content in ribonucleotides. Extraction with normal hydrochloric acid at 57–60° C. for 5–10 min. removes the ribonucleotides from the cells (Vendrely, 1946) but does not lower the affinity for basic dyes of the nuclear structure. If the cells are stained after hydrochloric acid extraction, little of the stain is retained by the cytoplasm and the nuclei stand out very clearly. Of many basic dyes tried Giemsa's stain has proved most satisfactory; the effect of the stain parallels exactly, but is more brilliant than that of the Feulgen test. Giemsa-stained nuclear structures in hydrochloric acid extracted material appear slightly larger than in Feulgen preparations.

The same result has recently been obtained by digesting fixed bacteria with the enzyme ribonuclease (Tulasne, Univ. Strasbourg).

In bacterial spores it is not a basophilic cytoplasm which prevents a view of the interior but the impenetrable spore membrane (of unknown composition). The staining properties of bacterial spores are radically altered after 10–20 min. in normal hydrochloric acid at room temperature. This simple expedient renders the spores transparent and reveals their relatively large refractile nuclei. The nuclei are superficially attached to, not contained in, the much less refractile, dormant cytoplasm. The chemical basis of the effect of hydrochloric acid on the spore membrane is not known. Changes in the arrangement of the nuclear structures precede the formation of spores. The process is an example of 'free cell formation' (in the cytoplasm of the spore-forming bacterium).

In the study of the nuclei of yeast cells extraction with warm hydrochloric acid before staining has proved quite as useful as in bacteria and has allowed the staining of the chromatinic bodies first described as nuclei by Badian, 1937. Schizosaccharomycetes have been found more rewarding subjects than *Saccharomyces cerevisiae*.

Hydrochloric acid extraction greatly facilitates the staining of the nuclei in whole-mount preparations (on cellophane) of fungal mycelia.

The method was illustrated with photomicrographs of bacteria, yeasts, and hyphae and conidia of *Penicillium notatum*, *Oospora lactis*, and *Mucor hiemalis*.

A. F. PARKER RHODES (Department of Genetics, Cambridge). Phenogenesis in fungi.

The action of genes in producing the visible characters of an organism is called Phenogenesis; its study belongs partly to biochemistry and partly to embryology. This paper considers the theory of the process as applied to fungi. The theory is based on two concepts, both of biochemical origin, viz.: Autonomy and Biodynamic Field. By their help much of the experimental observations on the development of plants and animals can be reduced to coherence.

Fungi differ from both animals and plants. Many groups of fungi are built of hyphae, and their tissues are thus usually anisotropic; this means that unlike other organisms they must have fields of two kinds, synhyphic (gradients along preferred direction of hyphae) and anthyphic (gradients across). Because inter-hyphal diffusion is usually easy anthyphic fields are open to environmental interference, whereas synhyphic ones can be made autonomous. It can be shown that such fungi can tolerate a much higher mutation rate among those genes which are called into play by synhyphic fields than among those

called into play by anthyphic ones; whence characters governed by anthyphic fields are either environmentally variable or of considerable stability.

Evidence is presented that single-gene variants in nature nearly always concern synhyphal characters. Genetic evolutionary implications are mentioned, and the need for experimental research stressed.

G. PONTECORVO (Department of Genetics, University of Glasgow).
Genetical aspects of heterokaryosis.

Heterokaryosis is the coexistence of nuclei not all genetically alike in a syncytial tissue. It may occur in any syncytial tissue of higher organisms, as well as of colonial micro-organisms, as a consequence of mutation. In most filamentous fungi, however, heterokaryosis is brought about regularly through an appropriate mechanism. Anastomoses between hyphae occur readily and if hyphae that fuse differ in the kind of nuclei they carried, a hypha with nuclei of two, or more, kinds may result. Heterokaryosis is widespread in homothallic, heterothallic and 'imperfect' species or strains.

Since the nuclei of different kinds in a heterokaryotic hypha can segregate (e.g. at 'cell' division, or in the formation of conidia, etc.), the alternation of hyphal fusions with segregation of whole nuclei provides a mechanism of genetical recombination additional to that of alternation of meiosis and fertilization known from classical genetics. The two mechanisms may or may not coexist in any particular species or strain, and the genetics of natural populations in fungi must therefore consider genetic systems of the classical types (based on sexual reproduction alone) as well as genetic systems based on heterokaryosis alone (or almost so) and mixed systems in which both heterokaryosis and sexual reproduction play important parts.

The physiological genetics of heterokaryons presents many new problems, e.g. (1) the action of allelomorphs carried in different nuclei in the same hypha (dominance, localized action, etc.); and (2) the mechanisms of control of the ratios of different kinds of nuclei within a hypha by internal and external conditions. Examples were given of how these and other problems are investigated by means of artificially synthesized heterokaryons carrying two or more kinds of 'labelled' nuclei.

K. MATHER (The John Innes Horticultural Institution, London). Genetical
flexibility and the breeding system in fungi.

The genetical flexibility of a sexually reproducing species depends upon the bringing together, by recombination, into one individual of genes from different parents. Such recombination can occur only in heterozygotes, resulting from cross-breeding. Flexibility is thus greatest in regularly cross-breeding species and least in regular in-breeders. Genes controlling the type of mating have an adaptive value through this effect on flexibility.

Cross-breeding is stimulated at two levels by genes in fungi. The commonest kind of heterothally prevents self-mating at the haploid level, where inbreeding would lead to immediate and complete loss of flexibility through homozygosis. Genetically more complex types of heterothally also reduce the relative frequency of mating between haploids from the same diploid zygote, so reducing inbreeding at the diploid level, where the loss of flexibility is slower but eventually complete.

Inbreeding can be advantageous by increasing the frequency of a highly adapted type, at the expense of flexibility. Inbreeding mechanisms appear to have been superimposed on relic cross-breeding mechanisms in fungi as in Angiosperms.

Some fungi have abandoned the sexual cycle and secure by heterokaryosis a kind of flexibility which would be impossible in highly differentiated organisms. The sexual cycle and its associated outbreeding devices, may persist in species which have adopted heterokaryosis.

H. L. K. WHITEHOUSE (Botany School, Cambridge). Evolutionary aspects
of heterothallism and heterokaryosis.

The simplest type of heterothallism, controlled by a gene locus with two allelomorphs, is found in the Mucorales, in at least seven orders of Ascomycetes, and in the Uredinales

and Ustilaginales. Heterothallism controlled by multiple allelomorphs at one or two loci has been recorded only in the Hymenomycetes (including the Tremellales), but probably also occurs in the Gasteromycetes*. Published data indicate that of approximately 130 species of Hymenomycetes that have been tested, 50 % have two loci for heterothallism, 40 % one locus and 10 % are homothallic, with no significant differences between different families. That *Auricularia* and *Exidia* in the Tremellales have multiple-allelomorph heterothallism (Barnett, 1937) like the Agaricales, implies that the Tremellales probably have a much closer affinity with the remainder of the Hymenomycetes than with the Uredinales with their two-allelomorph heterothallism.

In some heterothallic fungi, such as *Neurospora crassa*, heterokaryosis appears to be restricted to between strains of one mating type (Sansome, 1946). In many others, association of nuclei of different mating types is brought about at an early stage of the life history by the fusion of vegetative hyphae, and in these cases it would appear that differentiated sex organs, if present, must be inessential for the completion of the life cycle, e.g. Uredinales (Brown, 1935). Using the term heterokaryosis in the broad sense to cover all cases of hyphae containing two or more genetically unlike nuclei, irrespective of whether the association has any ultimate sexual significance or not, then in the selective advantages to a species of unrestricted heterokaryosis can be seen a possible explanation for the apparent progressive loss, first of the sex organs as structures essential for sexual reproduction, and then of the organs themselves, as one proceeds from the lowest to the highest groups of fungi.

In those heterothallic species in which heterokaryosis is restricted to mycelia of one mating type, multiple-allelomorph heterothallism would be disadvantageous compared with the two-allelomorph type in so far as it would restrict the possibility of heterokaryosis to a narrower field. Thus it is improbable that multiple-allelomorph heterothallism would acquire a selective advantage in evolution until the condition of unrestricted heterokaryosis had first been evolved.

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* Note added in proof. Fries (1940) found multiple-allelomorph heterothallism in the Nidulariales.

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VISIT

A visit was made to the Brewery and, by kind invitation of Mr H. J. Bunker, the Brewery Research Department of Barclay Perkins & Co. Ltd. of Southwark on the afternoon of Friday, 18 April 1947.

Meeting held in the Department of Botany, University College, Nottingham, at 11 a.m., on Saturday, 28 June 1947. The President, Prof. C. G. C. Chesters, in the Chair.

Morning Session

Mrs E. SANSOME. Mutation in Fungi imperfecti with special reference to *Penicillium notatum*.

G. C. M. HARRIS. The morphology of *Penicillium chrysogenum* in submerged culture.

Afternoon Session

P. T. THOMAS. Some aspects of the cytology of Fungi.

F. L. DRAYTON and J. W. GROVES. A new heterothallic *Stromatinia*.

F. C. ATKINS. A new species of *Verticillium* on mushroom in England.

Meeting held in the Department of Biology, Chelsea Polytechnic, London, at 11 a.m., on Saturday, 25 October 1947. Mr G. Smith, Vice-President, in the Chair.

The meeting took the form of an Exhibit from the Herbarium of the Imperial Mycological Institute, Kew, of some classical British moulds. The exhibit, which had been arranged by S. J. Hughes and M. B. Ellis, was introduced by E. W. Mason. H. A. Dade showed specimens from the Institute's culture collection and Miss J. Hickman demonstrated the indexing system used in the herbarium.

ANNUAL GENERAL MEETING, 1947

The fifty-first Annual General Meeting was held in the rooms of the Linnean Society of London at 12 noon on Saturday, 6 December 1947, with the President, Prof. C. G. C. Chesters, in the Chair.

After the Minutes of the previous Annual Meeting had been read and signed the President recorded with deep regret the deaths of two members, Mr G. H. Murray, who died when a prisoner of war in 1942, and Mr J. Wilton; and reviewed the year's activities.

The Treasurer, Mr W. Buddin, then presented his annual statement and drew attention to the increasing cost of the *Transactions*, the price of which to non-members had had to be increased. He urged contributors to present their results concisely and to make every effort to reduce the cost of corrections to the proofs which had been excessive for recent numbers.

The following Officers and new Members of the Council for 1948 were then elected: *President*, A. E. Musket; *Vice-Presidents*, P. O'Connor, and the two past-Presidents, C. G. C. Chesters and J. Ramsbottom; *Secretary*, C. J. Hickman; *Foray Secretary*, G. C. Ainsworth; *Treasurer*, W. Buddin; *Editors*, B. Barnes and W. C. Moore; *Members of the Council*, T. E. T. Bond, Miss M. P. English, G. Smith, and E. R. Wallace (to replace R. W. G. Dennis, C. G. Dobbs, C. J. Hickman, and G. Samuel). A. S. Boughey, R. W. Marsh and Miss F. J. Moore were elected as new members of the Plant Pathology Committee.

On a motion from the Chair, E. W. Swanton was elected as an Honorary Member. Nine new Members and three new Associates were elected, making fifty new Members and twenty new Associates for the year.

A recommendation to the Annual General Meeting from an ordinary meeting of the Society, held during the Autumn Foray at Exeter, that the presidential address should in future be delivered at the Autumn Foray and that the Annual General Meeting should be held later in the year was discussed. It was agreed that from 1948 the presidential address should be given at the Autumn Foray unless the President should decide otherwise.

After the programme for 1948 had been discussed, the meeting adjourned until 2 o'clock when the President delivered his address, 'Concerning fungi inhabiting the soil'; a vote of thanks to Prof. Chesters concluded the meeting.

G. C. AINSWORTH, *Secretary*

for the year ending 30 June 1947

CAPITAL RESERVE FUND ACCOUNT (incorporating the Robinson, Cheeseman and Printing Funds)
$$\left\{ \begin{array}{ll} 3\frac{1}{2}\% & \text{War Stock} \quad \pounds 500 \\ 3\% & \text{Defence Bonds} \quad \pounds 200 \\ 2\frac{1}{2}\% & \text{Defence Bonds} \quad \pounds 500 \end{array} \right\} \text{Total } \pounds 1200$$

Examined and found correct, W. C. Moore, 2 August 1947.

WALTER BUDDIN, Hon. Treasurer.

Donations to the Printing and Special Jubilee Funds from numerous members are gratefully acknowledged.

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